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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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SEPTEMBER 1916.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

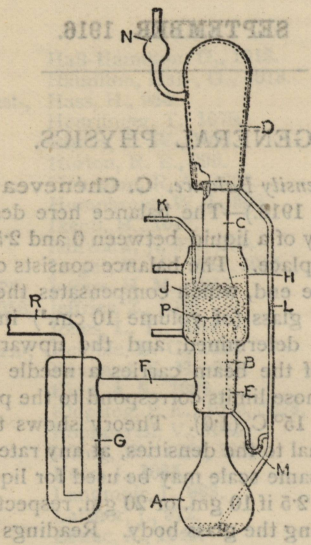
SEPTEMBER 1916.

GENERAL PHYSICS.

962. *Direct-reading Density Balance.* **C. Chéneveau.** (Comptes Rendus, 162. pp. 912–913, June 13, 1916.)—The balance here described gives, from a single reading, the density of a liquid between 0 and 2·5 correct to about one unit in the third decimal place. The balance consists of a bent beam, with a weight hanging from one end, which compensates the combined effects of the weight of a piece of glass (of volume 10 cm.^{3}) immersed in the liquid whose density is to be determined, and the upward pressure the glass experiences. One end of the beam carries a needle moving over a scale divided into 100 parts, whose limits correspond to the position of equilibrium in air (0) and in water at 15° C. (1·0). Theory shows that the readings are approximately proportional to the densities, at any rate to within one unit in the second place. The same scale may be used for liquids of densities from 1·0 to 2·0 or from 2·0 to 2·5 if 10 gm. or 20 gm. respectively is added to that side of the balance carrying the glass body. Readings to the third decimal place are always obtainable near the ends of the scale, and in the middle it is only necessary to replace one of the 10-gm. weights by a mass slightly different to get more exact readings there. The apparatus can also be used to give densities of solids with two readings. A. W.

963. *High Vacuum Mercury-vapour Pump.* **I. Langmuir.** (Phys. Rev. 8. pp. 48–51, July, 1916.)—Describes a mercury-vapour pump which is very rapid in action, and which is capable of producing very high vacua. The Gaede "diffusion" pump [Abs. 1178 (1915)] is necessarily slow in action on account of the slowness of diffusion through a narrow slit or a porous diaphragm. Several methods have now been found of introducing the gas to be exhausted more rapidly into the blast of mercury vapour, thus increasing very considerably the speed of the pump. One of the types of pump which has given satisfactory results is that shown in the Fig. In this apparatus a blast of mercury vapour passes upward from the heated flask A through the tubes B and C into the condenser D. Surrounding B is an annular space E connecting through F and the trap G with the vessel to be exhausted. The tube C is enlarged into a bulb H just above the upper end of the tube B. This enlargement is surrounded by a water condenser J,

from which water is removed at any desired height by means of the tube K, which is connected to a water aspirator. The mercury condensing in D and H returns to the flask by means of the tubes L and M. The tube N connects to the auxiliary pump, which should maintain a pressure considerably lower than the vapour pressure of the mercury in A. In this pump the mercury atoms escaping from the upper end of the tube B radiate out in all directions. Part of them pass up into C, but the larger part strike the walls of the enlargement H. If there is no water in the condenser J the mercury which condenses on the walls evaporates again nearly as fast as it condenses. The molecules passing from the end of the tube B towards the walls H collide with the molecules which have evaporated again, and may then be deflected downward into the annular space E. This blast of mercury vapour down through E prevents the gas from F from passing up into H, so that under



these conditions the gas from F may pass through the pump much more slowly than if no mercury-vapour were produced in A. On the other hand, when cold water circulates through the condenser J, all the mercury atoms striking the walls of H are condensed, so that no mercury passes down through E. The gas from F thus passes freely up through E, and when it meets the mercury-vapour blast at P is blown outward and upward along the walls of the condenser H, and finally forced into the main stream of mercury vapour passing up through C into the condenser D. The main advantages of this pump are (i) simplicity and reliability, (ii) extremely high speed, (iii) absence of lower limits to which the pressure may be reduced. The speed of such a pump has been determined for air and hydrogen, and the results are given for an 11-litre vessel. The pump here described is made of glass. Many pumps operating on these principles have also been made of sheet iron electrically welded. In a subsequent paper details will be given of other modifications of mercury-vapour pumps, some of which have marked advantages in simplicity of construction and in reliability of operation over that here described. One particularly efficient type of pump is made wholly of metal. A. W.

964. *Calibration of Divisions on Divided Circles.* **A. Verschaffel.** (Comptes Rendus, 162. pp. 935–939, June 19, 1916.)—It is shown how improvement may be made in the study of the divisions of a divided circle by using three pairs of diametrically situated reference points. Most circles of precision are now provided with six reading microscopes, but in the case of circles only having one pair the method may be utilised by employing two auxiliary microscopes. C. P. B.

965. *Dimensions of Physical Quantities.* **C. Runge.** (Phys. Zeits. 17. pp. 202–212, May 15, 1916.)—Dimensions are not only useful in checking equations in the way Fourier used them, but also in ascertaining the necessary relations of physical terms. As an example, take a pendulum swinging in an infinitesimal arc; g has the same dimensions at l/t^2, and the product gt^2/l has no dimensions and has the same value whatever be the units of length and time. Therefore $\sqrt{(g/l)} \times t =$ an absolute number; $t = f(l, g)$; and l, g cannot be combined to form a dimensionless function or absolute number. Cognate methods are applied to (1) the surface of a segment of a sphere; (2) the tension of a slingstone cord; (3) movement of a planet; (4) motion in an incompressible and in a compressible fluid; (5) energy radiated from a surface (inadequacy of Rayleigh's law shown, and Wien's and Stefan's formulæ arrived at with the aid of a quantum). In every case a dimensionless combination is equal either to an absolute number or to a function of groups of combinations. In particular classes of problems we may involve the different units in one another; for example, in gravitational problems (unit mass at unit distance produces unit acceleration) we may reach $[M] = [L^3/T^2]$; but this is not useful in other parts of the subject. Angles are usually considered to have no dimensions; but in particular problems it may be the ratio between two angles which has no dimensions, while the angles themselves ought to have dimensions. Logarithmic equations present anomalies, which can sometimes be done away with by giving suitable dimensions to the anti-logs. A. D.

966. *A Practical Application of Optical Stress Analysis.* **Mesnager.** (Ann. des Ponts et Chaussees, No. 4, 1913. Engineering, 101. pp. 468–470, May 19, 1916. Abstract.)—Engineers are being compelled to consider some very complicated problems in elasticity by the constantly increasing use of reinforced concrete structures, owing to the rigidity of the joints. By making due allowance for the stiffness of the joints and for the flange effect of the roadway, it is possible to effect a considerable economy in the material of bridges. The principles of optical stress analysis have already been described by Coker, but the author has applied them to determining the actual stresses existing in a reinforced concrete bridge which he designed to cross the Rhône at Balme. A glass model of the bridge was prepared, cemented to a glass framework, and the whole mounted on a wooden stand. Load was applied by means of calibrated spring balances. By the use of a graduated Babinet compensator in the polariscope it was found possible to determine the actual stresses in the model. An important point established by the investigation was that, owing to the assistance afforded by the roadway, there was, under any load, no stress whatever on the arch ring proper. The calculated stresses did not differ from the actual stresses by more than 14·7 %, which is less than the discrepancies generally observed in metallic bridges. Here errors of 25 % represent the average, and errors of 100 % are known. F. C. A. H. L.

967. *Determination of the Difference of Longitude between the Observatories of Paris and Washington.* **B. Baillaud.** (Comptes Rendus, 162. pp. 899–903, June 13, 1916.)—The author investigates the degree of accuracy reached by the employment of radio-telegraphy between Paris and Arlington [Abs. 1767 (1913)]. During the first experiments the time of transmission was taken as 0·033 sec., but in the present series the speed of Hertzian waves between the two stations named has been found to be 0·021 sec. Again, the difference of personal equation between two of the observers named was only in the present series 0·018 sec. In the observations dealt with in 1913 the figure was 0·065 sec. At the time now dealt with, Abraham organised at Paris and at Arlington a series of experiments of photographic registration of the signals. The present author is of opinion that this series affords more accuracy than those which involve the use of the telephone, owing to the elimination of the difference of personal equation of the observers, especially prevailing when the observers are exchanged and are rendered susceptible to the difference in nature of the radio-telegraphic signals of Paris and of Arlington.

With regard to disturbances engendered by atmospheric conditions and by other stations, registration at Arlington has been no easy matter. On the whole, however, during the period from 11th Dec. to 27th Feb., 23 very serviceable photographic records were obtained.

The results from the whole of the observations are summarised as follows :—

Observation by coincidences : American Mission, 36·658 secs. ; French Mission, 36·651 secs. ; and from photographic registration by Abraham's process, 36·682 secs. E. O. W.

968. *On Two Fundamental Problems in the Theory of Elasticity.* **C. E. Weatherburn.** (Phil. Mag. 32. pp. 15–38, July, 1916.)—Deals with the application of vector integral equations to problems of elastic equilibrium that require the determination of the displacement at any point of an elastic body when the value of the surface displacement is known or that of the surface traction. L. H. W.

969. *Internal Friction of Quartz Fibres at Low Temperatures.* **C. E. Guye** and **M. Einhorn-Bodzechowski.** (Archives des Sciences, 41. pp. 287–311, April ; 376-400, May, and pp. 457–468, June, 1916.)—A number of experiments have been made on the internal friction of quartz and glass fibres at the ordinary temperature and at low temperatures, the principal conclusions to which the results lead being as follows :—With quartz, cooling to —194° produces a permanent modification of the physical or chemical structure which is manifested in a persistent increase of the logarithmic decrement. After the decrement had been thus raised, it was found to remain constant throughout further experiments at all temperatures between 20° and —194°, which were the limits of temperature employed. In general the logarithmic decrement diminishes as the temperature falls, having at 0° a value one-half of that at 20° ; at —79° the decrease is less rapid but still marked, but further depression of the temperature produces only a very slight change. The second modulus of elasticity of quartz decreases by 2–3·5 % while the temperature falls from 0° to —194°. At 0° and at the ordinary temperature the log. decrement satisfies approximately Boltzmann's theory, according to which the log. decrement λ is independent of the period T ; at low temperatures, on the other hand, the decrement diminishes as the period increases. The theoretical condition enunciated by Voigt, namely, $\lambda T = \text{constant}$, is not

however satisfied, although there is an increasing tendency for it to be obeyed as the temperature continues to fall. The influence of the amplitude on the log. decrement is very slight, no such influence being detectable either at the ordinary temperature or at 0°.

With glass fibres, previously reheated, the decrement resumes its initial value when the fibre is brought back to the ordinary temperature from —194°. The decrement is almost independent of the amplitude of the oscillations, the amplitudes employed being not greater than 2·5°. As regards the variation of the decrement with temperature, glass fibres behave similarly to those of quartz. At ordinary temperatures and at 0° the decrement exhibits a value which is relatively high and independent of the period of the oscillations; at low temperatures the decrement is small, but it increases as the period diminishes, without however satisfying the condition, $\lambda T = \text{constant}$. Unlike quartz, glass fibres show an increase, amounting to 3 %, in the second modulus of elasticity when the temperature falls from 0° to —194°.

These results do not appear to favour the hypothesis that the internal friction tends to disappear completely at low temperatures, unless it is assumed that an appreciable part of the extremely small amount of energy absorbed is due to perturbing causes which have not yet been completely eliminated; such supposition is, however, scarcely justified by the results obtained. The effect observed at low temperatures is different in character from that manifested at high temperatures. The latter, which obeys Boltzmann's theory approximately, is explainable only by relatively complex considerations, whereas the loss of energy occurring at low temperatures may be attributed, at least partially, to an internal friction which is a function of the speed. T. H. P.

970. *National Physical Laboratory Annual Report*, 1915–1916. (Report [80 pp.], Teddington, 1916. Abstracts in Engineering, 101. pp. 604–606, June 23; 627–628, June 30, and 102. pp. 3–5, July 7, 1916. Electrician, 77. pp. 532–533, July 21; 565–566, July 28, and pp. 593–595, Aug. 4, 1916.)—Summarises the work of the laboratory during the past 12 months. In the *Engineering Department* investigations have been made of the fatigue resistance of steels under combined bending and twisting. The impact testing-machines of the department are described in detail, and it is noted that in these the anvil is free to swing as well as the hammer, the work absorbed by it being deduced from its angular displacement. Railway carriage couplings have been tested in an impact machine with special arrangements adapted to the problem of finding the number of blows of known force which a given coupling will withstand. The resistance of tension members of a structure to lateral vibrations has been investigated by using wires attached at either end by (*a*) ordinary screw connections, and (*b*) universal joints. It is found that whereas with the latter a load of one-third of the breaking load will be borne for an unlimited number of vibrations by a high-class material, with the former, on the other hand, fracture will take place after a few hours under one-sixth of the breaking load. The fatigue strength, under stress reversals, of the spruce wood wanted for aeroplane wing spars has been determined by the Wöhler method, and it is found that the safe limit of stress of this wood is only 1/4 of the ultimate strength, whereas it is about 1/3 in the case of steel. The investigation of the hardness and wear of metals has been continued. A description is given of the method of investigating the rate of growth of cracks in the buildings of the Tower of London. The method of calibration of testing machines is also described. Steam-joint packings of British manu-

facture have been tested at the laboratory and joint rings ranging from 1/32 to 1/8 in. in thickness have been made which will successfully withstand pressures of 250 lbs. per sq. in. at a temperature of 1000° to 1100° F., without any sign of breaking down. A comparison of the relative merits of kapok and cork for use in floats has been carried out. A description is given of the two new air channels, 4 ft. and 7 ft. respectively, which have been installed in the *Aeronautics Division*, and the special problems now undergoing investigation are enumerated. Further tests have been made of road materials.

In the *Metallurgy and Chemistry Department* research on optical glass has taken a prominent place in the work of the past year, and the research on alloys, particularly the Al-Zn-Cu alloys, has been resumed. In the *Froude National Tank* experiments on the effect of adding resistance to different parts of a ship's hull have proved the importance of keeping all appendages from the bow. As regards the relation between skin friction and temperature, model experiments indicate a diminution of the frictional resistance of 3%, for a rise of 10 deg. F. In the *Physics Department* the testing of prismatic and liquid compasses, and of the magnetic properties of steel have occupied much attention. In photometry the testing of radium-painted dials for aeroplanes has been undertaken. In the *Heat Division* the heat insulation of refractories is being investigated, while the experiments on the heat losses from surfaces are being continued. British-made porcelains used for pyrometer sheaths have been examined for permeability to the furnace gases by an ingenious method. The thermometers tested have both decreased in number and deteriorated in quality. The additions to, and work of the *Radium and X-ray section* are summarised. In the *Metrology Department* the testing of gauges and screw gauges has been undertaken for the Ministry of Munitions, and most of the research work has had to be abandoned. In the *Optics Department* the apparatus for the testing of optical glass has been elaborated, and the results of the investigation and design of lenses for ships' navigation lights have been published. *Tide predictions* for Brisbane and Koh Hlak (Siam) are in progress. J. W. T. W.

971. *The Deviations from the Vertical at Paris.* **L. Eblé.** (Comptes Rendus, 162. pp. 880–883, June 5, 1916.)—Acccording to the observations of Hecker from 1902 to 1909, the deviations from the vertical at Potsdam corresponding to the deformations of the earth's crust under the influence of the moon and the sun are relatively greater along the parallel than along the meridian. To investigate the causes of this dissymetry the International Association of Seismology proposed to the Director of the Central Meteorological Office to continue the experiments at Paris, where the cellars of the observatory would permit of the apparatus being maintained at an invariable temperature. The apparatus has functioned since the middle of 1912. It consists of two horizontal pendulums oriented in the directions N.–S. and E.–W., the displacements being photographically registered. The apparatus resolves the movements from the vertical into two components, N.–S. and E.–W. For each of these the effect of the solar and the lunar attractions has been separated by the procedure currently employed in the calculation of the tides. Then, for each month, and for the entire year, the mean diurnal variations of the deviation under the influence separately of the sun and of the moon have been established. Each has been represented by a development in harmonic series.

The action of temperature appears to be too considerable to permit of any conclusion being drawn from the form of the first two developments.

But the action of the lunar attraction can be considered sufficiently exact, and the amplitude of the corresponding periodic variation as equal to 0·00537″ for the component N.–S. and 0·01005″ for the component E.–W. Calculation establishes that if the earth were absolutely rigid these deviations ought to be 0·00821″ and 0·01091″ respectively. The ratio of the observed to the calculated amplitude is then 0·65 and 0·92 for the two respective cases. Moreover, the great axis of the double ellipse described by the plumb-line ought to be directed along the parallel. It makes, on the contrary, with it an angle of 22°.

The mean of the experiments of Hecker at Potsdam has given for the above ratios 0·43 and 0·66 respectively, and the most recent experiments of Michelson at Chicago 0·52 and 0·71. In all these cases the deviation observed approaches more to the theoretical deviation in the sense of the parallel than in the sense of the meridian, as if the earth were much less rigid in the meridianal sense than in the perpendicular sense. The deviations from the vertical correspond to a rigidity sensibly greater at Paris than at Potsdam. To verify results the observations for 1914 have been subjected to the same calculations and the important terms, that is to say those which correspond to the lunar semi-diurnal attraction, were found to preserve the same order of magnitude. The amplitude observed represents 0·60 for the component N.–S. and 0·93 for the component E.–W. of the theoretical amplitude.

The registration has been pursued during the year 1915, and the first half of the current year. E. O. W.

972. *Gravitation and Temperature.* **P. E. Shaw.** (Nature, 97. pp. 400–401, July 13, 1916.)—Replying to J. L. [see Abs. 860, 861 (1916)] the author reviews the work of Kepler (third law), Bessel's pendulum experiments, the results obtained by Poynting and Phillips, and his own recent work. He then discusses the formula suggested by Poynting and Phillips, namely, $F = \frac{GMm}{d^2}\left(1 + \alpha\frac{MT + mt}{M + m}\right)$, attributing the temperature term of the attraction to a vibratory motion like Challis's wave theory of gravitation, or to some resonance effect as suggested by C. V. Burton.

It was also pointed out that the temperature effect of gravitation observed by the author is of the order one-seventh of the cubical expansion of the substance (lead) used for the large masses which were heated. **J. L[armor].** (Ibid. p. 421, July 20, 1916.) E. H. B.

973. *Gravitation and Electric Charges.* **E. H. Kennard.** (Science, 43. pp. 928–929, June 30, 1916.)—Recently F. E. Nipher suggested that determinations of the gravitation constant might be in error, owing to the force between electric charges on the attracting masses [see Abs. 640 (1916)]. The point is interesting, but in estimating the possible magnitude of the effect the author seems to have erred by using for the capacity of the sphere the value which only holds when the sphere is alone in space. It is concluded, therefore, that any error due to electrical attraction is hardly likely to exceed the very small discrepancies between the best modern determinations of the constant. **C. Davisson.** (Science, 43. p. 929, June 30, 1916.)—Referring to F. E. Nipher's criticism about electrical disturbances in gravitation determinations [see Abs. 640 (1916)] Davisson points out here that such determinations were carried out with systems shielded in some way, *e.g.*, in Boys' experiment the torsional system was enclosed in a double metal casing and the apparatus installed in an underground vault. There is little reason to think that the error in "G" is more than 1 in 3000. E. H. B.

974. *Impossibility of an Absolute Mass System as a Consequence of the New Relativity Theory of Gravitation.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 431–436, May, 1916.)—The present paper is an extension of previous investigations by the author on this subject [see Abs. 752, 913, and 988 (1916)]. For the dimensional presentation of all physical quantities, 5 fundamental magnitudes are necessary—namely : length, time, mass, electrical quantity, and temperature. On the other hand, nature possesses 5 independent universal constants, viz., Newton's gravitation, Planck's radiation, Boltzmann's entropy, light velocity *in vacuo*, and the vacuo dielectric (or magnetic permeability) constants. These latter cannot be determined independent of each other, since the fundamental quantities depend upon choice of units. The units can be made independent of any particular substance if given values are assigned to the 5 fundamental constants, and such a mass system was termed by Planck a natural system. The absolute significance of the system, however, was not evident until the existence of the radiation constant had been established. The introduction of a new physical quantity, therefore, must be accompanied by the simultaneous appearance of a new universal constant if the natural mass system is to be maintained. When the principle of relativity is applied to gravitation, however, it is found that one of the 5 universal constants loses its characteristics, *e.g.*, according to Nordström the gravitational constant is without dimensions, while Einstein, Abraham, and the present author find the vacuum light-velocity to be identical with the gravitational potential. In consequence, before the natural mass system can be established as absolute another constant must be found. An investigation is given in the paper of finding whether the value of the gravitational potential at infinity, which is introduced mathematically as the integration constant of the field equation and is a positive quantity, can be regarded as such a constant. It is found that the mass system would in such a case depend on the position of our part of the universe, and, in consequence, could not be regarded as an absolute natural system. The same result has been obtained by the author using Tolman's "Principle of Similitude." The author remarks, however, that the provisional mass system, obtained by the introduction of the gravitational potential at infinity as a constant, remains absolute for all practical purposes—a result which applies to the unit of time. H. H. Ho.

975. *R. C. Tolman's Principle of Similitude.* **[Mrs.] T. Ehrenfest-Afanassjewa.** (Phys. Rev. 8. pp. 1–7, July, 1916.)—An accurate analysis shows that Tolman's considerations possess at least a close connection with the reduction to a definite hypothesis of the conviction of the homogeneity of all the equations of physics—a conviction which is commonly used without any foundation. This is not the intention of the author, as appears from his third paper on the same subject [see Abs. 1488 (1915)], yet he really does nothing else but construct a system of dimensions of his own (indeed one that in some respects deviates from the C.G.S. system), and he examines all equations with a view to homogeneity *as regards this system of dimensions.*

The present authoress has already treated from a considerably different point of view the mathematical relations which form the basis of all such considerations. The relation between the transformation with the aid of a model and the transformation of units is also treated there, but in the present paper the subject is treated from Tolman's point of view.

It is concluded that the widely spread conviction of the homogeneity of all physical equations with regard to the C.G.S. system would be reduced to

the hypothesis of the possibility of a model universe, if one could be sure: (1) that a model universe in the sense defined is possible; (2) that we possess all equations which are wanted for a full description of the whole universe; (3) that the latter condition is especially fulfilled by those equations which in the C.G.S. system serve to fix the dimensions of the different quantities.

E. H. B.

976. *Homogeneity of Physical Equations.* **R. C. Tolman.** (Phys. Rev. 8. pp. 8–11, July, 1916.)—Mrs. Ehrenfest-Afanassjewa has presented in the paper on Similitude [see preceding Abs.] a very satisfactory and general treatment of the conditions which must be fulfilled if a set of physical equations are to be homogeneous with respect to a given transformation. She has also shown that the possibility of constructing a miniature (model) universe, in which all the laws of physical behaviour would be identical even to numerical coefficients with those in our own universe, depends on the possibility of finding a homogeneous transformation for *all* the fundamental equations of physics in which at least one of the factors can be taken as arbitrary. With these conclusions the present author agrees entirely.

He agrees also that the principles of dimensional homogeneity and of similitude can be shown to involve *three* arbitrary multipliers and only *one* arbitrary multiplier respectively. But he objects that, because of this, the theory of similitude should be spoken of as merely another system of dimensions differing from the C.G.S. system. Although this method of speaking is perhaps logically possible, the present author holds it to be *very undesirable*, since he does not believe that the principle of similitude determines what is ordinarily meant by a set of dimensions.

He contends that the dimensions of a quantity may be best regarded as a shorthand statement of the definition of that kind of quantity in terms of certain fundamental kinds of quantity, and hence also as an expression of the essential physical nature of the quantity in question. E. H. B.

977. *Motion of Solids in a Liquid possessing Vorticity.* **J. Proudman.** (Roy. Soc., Proc. 92. pp. 408–424, July 1, 1916.)—The paper contains investigations which are an extension of some as yet unpublished results obtained by G. I. Taylor. The equations of motion of any system of solids in a liquid which moves without vorticity were obtained by Kelvin by a method based on that of ignorable coordinates in ordinary dynamics. Various writers, such as Lamb, have obtained them by an adaptation to hydrodynamics of Lagrange's original method. Lamb's work leads to some hydrokinematical relations which are referred to in the paper. For the rotational problems under discussion an attempt to obtain a Lagrangian function has only been successful in one case, namely, the two-dimensional motion, with uniform vorticity, which at infinity reduces to a rotation about an axis. In other cases, instead of bringing into the equations the effects of the inertia of the solids, restriction is made to the finding of the generalised components of liquid pressure on the solids. For two-dimensional problems with uniform vorticity this is immediately effected by an extension of the ordinary pressure formula. For three-dimensional problems, constant uniform vorticity becomes impossible, and the motion of the liquid depends not only on the instantaneous motion of the solids but also on its past state. Throughout the consideration of these problems the motion is referred to axes which rotate with constant angular velocity. The determination of the pressure is first

reduced to a solution of a Neumann's problem, and the method is then applied to calculate the pressure components in any case of initial motion. Two general problems of continued motion are then formally solved by means of infinite power series in the time. The first of these concerns the evolution of any given small relative motion inside a rotating envelope ; the second concerns the motion of a body without relative rotation in a liquid which extends to infinity and is there at relative rest. The coefficients in the power series are derived from a certain sequence of functions of position, and each function may be found from the two immediately preceding ones by the solution of a Neumann's problem. The convergence of the power series is not here established, but for the special case of a spherical boundary the series have been shown to be highly convergent. To render the problems mathematically determinate in as simple a way as possible, motion at the outer boundary or infinity is prescribed. H. H. Ho.

978. *The Flow of Air through Nozzles.* **T. B. Morley.** (Inst. Mech. Eng., J. 2. pp. 51–89 ; Disc., 89–92, Feb., and 3. pp. 93–110, March, 1916. Engineering, 101. pp. 91–94, Jan. 28, and pp. 102–104, Feb. 4, 1916.)—The primary object of the experiments was to compare various forms of nozzles, with regard to their effectiveness for the production of jets of air having as high a mean velocity as possible. This forms the subject of Section I, in which the greater part refers to experiments on nozzles only. The nozzles were all made of gun-metal, and the features, the influence of which was investigated, were the entrance curves, the rate of divergence after the throat, and the length. The latter two together determine the ratio of the cross-sections at the outlet and at the throat. With one exception, the nozzles were originally of the convergent-divergent type, and after being tested in this form were cut down to successively shorter lengths. Several diagrams illustrate the types of nozzle used. The method adopted for the measurement of the discharge consisted in determining the time rate of change of pressure and of temperature in a large closed reservoir from which air was allowed to escape into the atmosphere through the nozzle under test. The methods of measuring the velocity of the air-jets that were considered were (*a*) the Pitot tube, (*b*) measurement of the reaction, and (*c*) measurement of the impact of the jet upon a surface of known form, the most suitable surface being a flat plate placed normally to the jet and large enough to ensure that the air should leave the plate tangentially. In comparing these methods, it was always kept in mind that the mean or "effective" velocity of the jet was the object aimed at—that is, the measure of the effectiveness of the jet for employment in, say, a compressed-air turbine or for jet-propulsion by reaction. After careful experimentation the impact method was first adopted, but in view of the differences discovered when the plate was at varying distances from the nozzles, the reaction method was also employed. The apparatus used receives most detailed description, while a large number of diagrams are given to illustrate the results. According to the theory, we should expect the shorter nozzles to be the best for low pressures, but that at higher pressures rather longer nozzles, of the same taper, should be the best. The range of pressures available in the experiments was too limited to permit of full investigation of this point, but so far as the tests go, the nozzle which is better than another of the same group (that is, having the same throat and same taper) at one pressure is found to be better at all pressures. From the absolute values of the velocities obtained with the best forms of nozzle it was found that those based upon the reactions are practically equal to the

theoretical values, while the impact experiments lead to figures some 12 % higher. The discrepancy in the results of the two methods forms the subject of a separate investigation which is described in Section II, and from which it appears that the velocity calculated from the reaction is correct. The efficiency of the best forms of nozzle is thus practically unity. In view of the good results obtained with very short nozzles, two simple orifices were also tested, and were found to give reaction and impact results very similar to those obtained for the nozzles. The author summarises his conclusions as follows:—In the flow of air through an orifice it is evident that a *vena contracta* exists, the size of which depends upon the pressure of the air supply, so that the discharge coefficient is variable, increasing as the pressure increases. A convergent nozzle with a rounded inlet may have a discharge coefficient of 0·98 if it is short; and, so long as there is no sharp change of curvature, alterations in the form of the entrance curve have very little effect upon the coefficient. The addition of a divergent part after the throat slightly reduces the coefficient unless the taper is very gradual. The efficiency of nozzles and orifices, as measured by the mean velocity of the jet produced, is very high indeed, becoming practically unity if they are of the proper form. For pressures up to 50 lb. per sq. in., orifices and convergent nozzles are practically equally good. While the addition of a short and very gradually divergent part to a nozzle may slightly improve its efficiency, it appears that in general, and within the pressure limits of the experiment, a divergent part added to an air-nozzle is not an advantage, and if such a part has more than a gradual taper, it reduces the efficiency of the nozzle very seriously. The effect of extra length is not so deleterious as that of a rapid rate of divergence. In the case of divergent nozzles, an entrance curve of about 0·5 in. radius gives an appreciably higher efficiency than one of 0·1 in. radius.

Section II deals with the nature of the impact produced by a jet upon a flat plate, and its relationship to the reaction of the jet. An important deduction from the results is that, for the determination of jet velocities, it is better to measure the reaction of the jet rather than the impact, unless special means are employed to check, or to neutralise the effect of air-currents induced in the atmosphere surrounding the jet.

A discussion concludes the paper. H. H. Ho.

979. *Flow of Compressible Fluid past an Obstacle.* **Rayleigh.** (Phil. Mag. 32. pp. 1–6, July, 1916.)—It is well known that according to classical hydrodynamics a steady stream of frictionless incompressible fluid exercises no resultant force upon an obstacle, such as a rigid sphere, immersed in it. The development of a "resistance" is usually attributed to viscosity, or when there is a sharp edge to the negative pressure which may accompany it. The absence of resistance is asserted for an *incompressible* fluid; but it can hardly be supposed that a small degree of compressibility, as in water, would affect the conclusion. On the other hand, high relative velocities, exceeding that of sound in the fluid, must entirely alter the conditions. For cylinders and spheres the case is worked out for compressible fluids, and it is found that for speeds small compared with that of sound in the fluid there can be no resistance as the result of compressibility. E. H. B.

980. *Brasher Air Breakwater.* (Engineering, 122. p. 478, June 9, 1916.)—Shows by a diagram how the air-jets under the waves so change the air pressures at the surface as to quiet the waves instead of allowing the wind to aggravate their intensity. E. H. B.

981. *Turbulent Motion of Fluids in a Cylindrical Tube.* **P. Zeeman.** (K. Akad. Amsterdam, Proc. 18. No. 8. pp. 1240–1247, 1916.)—Describes an optical method for determining the ratio between the mean and max. velocities in the turbulent motion of fluids in a cylindrical tube. In the author's experiments on the Fresnel coefficient for different colours [Abs. 1523 (1915)] the mean velocity of the water current was found by determining the total volume that had passed through the tubes. The max. velocity near the axis of the tubes was then found by dividing the mean velocity by 0·84. This number has now been re-determined under the same conditions as occur in the Fizeau experiment, and no measuring apparatus was introduced into the tube. Full details of the method, which involves the use of a rotating mirror for determining the velocities of small gas-bubbles carried along by the water, are given. The mean result of the observations gives a value 0·843 for the ratio of the mean and max. velocities. A. W.

982. *Equilibriating Masses rotating at High Velocities.* **C. L. Ricci.** (Accad. Sci. Torino, Atti, 51. 2a. pp. 86–111, and 3a. pp. 160–198, 1915–1916.)—The first part of a mathematical treatise on the subject of applying corrections to rotating masses so as to make the axis of rotation and the principal axis of inertia coincide. The correction may be computed from observations taken by a dynamic method in accordance with a theory which analyses the whole system of centrifugal forces concerned. According to the author's method, comparison of the original motion with that observed when a single correction-mass is added enables the whole correction required to be very approximately computed. In taking the observations, a stroboscopic method is used.

A. D.

983. *Negative Liquid Pressure at High Temperatures.* **S. Skinner.** (Nature, 97. p. 402, July 13, 1916.)—In the paper by the author and F. Entwistle upon the effect of temperature on the hissing of water when flowing through a constricted tube [see Abs. 1440 (1915)] a determination was made of the temperature coefficient of an effect which indicates that the tensile strength of water would be zero at a temperature between 279° C. and 363° C., with a mean from all the experiments published of 328° C. J. Larmor's calculated result, 265° C., quoted by him (Nature, June 29), agrees satisfactorily with the experimental value, if we take into account the difficulty of getting the precise point at which hissing ceases, and that the result was obtained by extrapolation from observations taken at temperatures between 12° and 99° C. The author's own view was that the tensile strength of a liquid would become zero at its critical temperature. It is of very great interest that J. Larmor has been able to show mathematically that the negative pressure can only subsist at absolute temperatures below 27/32 of the critical temperature of a substance. E. H. B.

984. *A Double Screw Propeller for Ships.* **H. Hass.** (Zeits. Vereines Deutsch. Ing. 60. pp. 521–528, June 24, 1916.)—Describes experiments on the use of a double screw propeller consisting of two screws placed coaxially one behind the other and rotating in opposite directions either with the same or with different speeds. The arrangement and design of the screws is described at length in the paper with photographs. In the actual trials the increase of speed attained with the double screw was inconsiderable, but it was stated that the boat was under better control with the double screw than with an ordinary single screw. J. W. T. W.

985. *Brownian Movement.* **J. D. van der Waals, Jr.,** and **[Miss] A. Snethlage.** (K. Akad. Amsterdam, Proc. 18. No. 8. pp. 1322–1334, 1916.)—A mathematical discussion of the expression for the average displacement Δ in time t in consequence of the Brownian movement. The authors obtain the formula $\Delta^2 = (3t/4\rho a^2)\sqrt{(RTm/2\pi N)}$. [See Abs. 960 (1907).] E. H. B.

986. *Crystals and Crystal-forces.* **F. E. Wright.** (Washington Acad. Sci., J. 6. pp. 326–332, June 4, 1916. Paper read before the Geological Soc. of America, Dec., 1915.)—Recent researches have shown the reality and importance of crystal-forces, and the problem of actually measuring these forces is rapidly approaching the stage at which direct experimental research will become possible. In preparation for this stage the Geophysical Laboratory is making arrangements for measuring accurately the changes in the crystallographic and optical constants of crystals from —190° to + 1600° C., and from 1 to 2000 atmos. pressure. T. M. L.

987. *Spreading of Pure and Mixed Liquids on Water.* **A. Pockels.** (Phys. Zeits. 17. pp. 142–145, April 15, 1916.)—The spreading of a drop of a liquid immiscible with water on the surface of the latter depends on the volatility of the liquid, on whether a surface solution is formed, on whether the liquid is soluble in the interior of the water, etc. The saturated hydrocarbons are inactive, that is, they form no solution stream. If γ_1 and γ_2 are the surface tensions of water and the other liquid respectively, γ_{12} the tension of their common surface, a drop of an inactive liquid will spread out on a pure water surface if $\gamma_1 > \gamma_2 + \gamma_{12}$, and if the surface becomes contaminated, the spreading ceases as soon as the diminution $\gamma_1' = \gamma_E = \gamma_2 + \gamma_{12}$. Benzine and petroleum spread out to thin coloured films, but the best refined American petroleum gives a lens-shaped globule, and the same is the case with a drop of liquefied paraffin wax on hot water. In these last cases the equilibrium tension, or $\gamma_2 + \gamma_{12}$, is greater than the normal surface-tension of water at the same temperature [see Hardy, Abs. 1394 (1913)]. It is possible that individual saturated hydrocarbons never spread. Benzene would, since $\gamma_2 + \gamma_{12} < \gamma_1$, spread over the whole surface of water, if it were not prevented by the adsorption of its vapour at the surface of the water, this reducing γ_1 to 0·88 times its normal value; colours appear on the layer only after prolonged evaporation, possibly owing to increasing concentration of dissolved impurities, but the vapour of this thin layer passes back and dissolves in the drop, γ_1 becoming normal again when all has evaporated. If a small water surface covered with a deep layer of benzene is expanded, the layer breaks before interference colours appear. With ether, the behaviour is similar to but more pronounced than that of benzene, so that ether never spreads out to a coloured layer, but stands steadily on an abnormal surface in a thick layer, the equilibrium tension being 0·42 times the normal value. Aniline ($\gamma_E = 0{\cdot}71$) and carbon disulphide ($\gamma_E > 1$) do not spread out on water.

With oleic acid, stearic acid, and purified olive oil, spreading is opposed by the formation of a surface solution, and the saturation tension (γ_s) of the latter, which forms almost instantaneously on a small surface, plays a rôle similar to that of the vapour anomalies with benzene; none of these liquids exhibits spreading. Measurements of γ_s at different temperatures show that γ_s diminishes as the temperature rises, but much more slowly than the normal tension of water (γ_1), so that the max. anomaly produced by an active substance is greater on cold water than on hot.

A mixture of two liquids, neither of which alone spreads out—such as

pure petroleum with purified olive oil or stearic acid—spreads out to a layer giving interference colours; the addition of an active substance to one less active or inactive strongly depresses γ_{12} and therefore γ_g, while the diminished γ_s of the surrounding water surface is not reached. The spreading attains a maximum for a definite concentration. Consideration of the results obtained leads to the conclusion that no perfectly pure, chemically individual liquid immiscible with water will spread out on the latter to a thin coherent layer.

T. H. P.

988. *Tolman's Principle of Similarity and the Law of Gravitation.* **J. Ishiwara.** (Tôhoku Univ., Sci. Reports, 5. No. 1. pp. 33–43, 1916.)—The principle of similarity introduced by R. C. Tolman [see Abs. 1488 (1915)] as a new physical principle is stated as follows: The fundamental entities of which the physical universe is made up are of such a nature that a completely similar universe to the actual one can be constructed from them in miniature. This derived universe Tolman constructs on the principle that all physically variable quantities change their numerical values in certain fixed ratios, *e.g.* between the lengths l and l', intervals t and t', masses m and m', electricities e and e', temperatures T and T' there arise the relationships: $l' = xl$, $t' = xt$, $m' = x^{-1}m$, $e' = xe$, $T' = x^{-1}T$, where x is any suitable number. Transformation formulæ for all other quantities follow by dimensional considerations. This system of transformations has been extended by Tolman to functional relationships between different quantities. By many varied applications Tolman found complete agreement in the case of all natural laws with the single exception of the law of gravitation, and on this ground he doubted the validity of the Newtonian law. Nordström is convinced that while his gravitational theory is in opposition to that of Newton it is compatible with that of Tolman. The results of the present investigation are as follows:—(1) The Tolman principle is to be regarded as a special result of the impossibility of absolute natural units of mass. (2) Every rational gravitation theory (*e.g.* that of Nordström) supports this impossibility. Only four independent natural constants are recognised whose values may be universally fixed, while for complete determination of complete mass systems five fundamental mass units are requisite. (3) Tolman's mass transformation system is so arranged that the four natural constants are invariant, and it depends, therefore, on a special gravitation theory. (4) For the determination of the functional relationship between different states of matter the dimensional method is much more suitable than Tolman's scheme of mass transformation.

H. H. Ho.

989. *Measurement of Horizontal and Vertical Movement in the Atmosphere.* **M. Tenani.** (N. Cimento, 11. pp. 87–94, Jan.–Feb., 1916.)—A small captive balloon is employed. The curve of the cord is assumed to be a catenary. The problem then is—Given (1) the weight of the cord per unit of length, (2) the tension at the lower end of the cord (measured by a dynamometer), and (3) the angle made with the horizontal by the lower end of the cord, find (*a*) the tension at the upper end of the cord and (*b*) its direction. These, with the known ascensional force of the balloon, enable the required air-current data to be computed.

A. D.

990. *The Rainfall of California.* **A. G. McAdie.** (Univ. of California, Publ. in Geography, 1. No. 4. pp. 127–240, Feb. 19, 1914.)—This describes in considerable detail the amount and character of the rain and snowfall over

the various parts of the State of California. The average annual fall varies from about 2 in. in the inland districts of the extreme south to over 50 in. on the western slopes of the Coast Range in the extreme north, and of the Sierra Nevadas in the east of the State. The distribution is controlled mainly by five factors: (1) position and intensity of the Aleutian low-pressure area and the continental high-pressure area, (2) the prevailing winds which usually blow from a westerly point, especially in winter, (3) the proximity of the Pacific Ocean, (4) the topography, and (5) ocean currents. Of these (1) decides mainly the general character of the season, and explains why the north is generally wet and the south is generally dry; (2) and (4) account for the high rainfall on the western slopes, and the dry character of the area between the Coast Range and the Sierra Nevadas; (3) in conjunction with (2) provides the material for the rain, and (5) influences rainfall through the medium of air temperature.

There is a very marked seasonal variation of rain, the summer months being very dry, and practically rainless in many localities, while in general the winter months are very wet. This is largely due to the fact that the prevailing air currents are different in the two seasons: in winter, when the Aleutian low-pressure system is well developed, strong west winds prevail; in summer, on the other hand, the winds are light and more variable, a NNW. wind predominating.

The variations from year to year are large: for example, Jan., 1902, was a dry month with less than 2 in. of rain over the greater part of the State, a small patch with 6 in. being shown in the extreme north-west; while in a wet Jan. the area with less than 2 in. is a much smaller one in the south-east of the State, and there is a large area in the north and west where rainfall exceeds 8 in.

Much information is given about heavy falls in short periods; perhaps the most remarkable is a fall of 11·5 in. in 80 minutes on Aug. 12, 1891, at Campo.

R. C.

991. *Monthly Distribution of Mean Cloudiness over France.* **G. Bigourdan.** (Comptes Rendus, 162. pp. 620–625, April 25, 1916.)—This gives 13 charts showing the mean distribution, expressed in percentages, of the proportion of the sky covered with cloud, for the 12 months and the whole year. On the average of the months the Mediterranean coast has less than 35 % of cloud, and cloudiness increases with latitude generally up to about 65 % on the north coast of France. There are secondary maxima of cloud over the Pyrenees and the Jura and Vosges Mountains. The individual monthly charts are on the whole similar in character to the annual chart, the cloudiest month being Jan., with 40 % to more than 70 % of cloud, and the sunniest month July, with less than 25 % cloud on the Riviera to less than 60 % on the north coast. June, July, and Aug. are all very sunny months on the Mediterranean coast.

R. C.

992. *Researches in Seasonal Correlations.* **T. Okada.** (Meteorolog. Soc. of Japan, J. 34. No. 12. Dec., 1915. Monthly Weather Rev. 44. pp. 17–21, Jan., 1916. Reprint.)—The summer temperature of north-eastern Japan is closely related to the strength of the Pacific anticyclone which prevails at that season of the year, and the author has noticed that there appears to be a connection between the intensity of this anticyclone in the summer and that of the continental anticyclone over Asia in the preceding winter or spring. He is thus led to attempt to establish a connection between the winter conti-

nental anticyclone and the temperature of Japan some months later. As a measure of the anticyclonic intensity he uses the pressure gradient in the neighbourhood of Zikawei, preferring this method to that of using a single-pressure reading at the centre of the high-pressure area. These mean barometric gradients for March are correlated with the temperatures of the following July and Aug. at three stations on the east coast of Japan, leading to coefficients of + 0·76, + 0·78, and + 0·68 for the three stations, based on a period of 20 years' observations. Other correlations on the same lines are tried but lead to lower coefficients. That between Zikawei pressure gradient for March and sunshine at various stations on the east side of Japan in July and Aug. lies between + 0·4 and + 0·5. This is regarded as being at least suggestive, and gives a hint for the physical interpretation of the correlation between barometric gradient and temperature. J. S. Di.

993. *Wind Velocity and Elevation.* **W. J. Humphreys.** (Monthly Weather Rev. 44. pp. 14–17, Jan., 1916.)—A diagram is reproduced showing the changes of wind velocity with height found from 200 pilot balloon ascents made at Vigna di Valle, about 40 km. NW. of Rome. The chief features exhibited are (*a*) a region of rapid increase of velocity with height extending from the surface (272 m. above M.S.L.) to 600 m., (*b*) a region of decrease of velocity with increase of altitude followed by irregular changes up to 1800 m., and (*c*) a region of approximately constant increase of velocity with increase of elevation, which it is known extends practically to the top of the troposphere. The changes in regions (*a*) and (*b*) are ascribed to surface friction and the convective mixing of divergent currents. It is to the explanation of the steady increase in region (*c*) which lies above the region of surface influence that the paper is devoted. The following assumptions are made: (1) that the temperature distribution is the same along all meridians, increasing from pole to equator, (2) that the temperature change from one latitude to another is the same at all levels up to 10 or 12 km., and (6) that sea-level pressure is the same at all latitudes. It is then calculated that from below 5 km. to above 10 km. height the horizontal N.–S. pressure gradient established by the temperature difference between adjacent regions is roughly constant. This conclusion is supported by the results of observations. If the "geostrophic" wind V be deduced from this calculated pressure gradient by the ordinary formula $\gamma/\rho = 2\omega V \sin\phi$ (where γ = horizontal pressure gradient, ρ = air density, ω = angular velocity of the earth, ϕ = latitude), it follows that the mass of air crossing unit area per unit time over any place tends to remain constant with change of altitude from 5 km. above M.S.L. to the base of the stratosphere, thus providing a theoretical basis for Egnell's law. When allowance is made for the variation of density with height it is found that the velocity will be roughly proportional to the height above M.S.L., which is in accordance with the facts disclosed in the diagram referred to above. In the region of the stratosphere the horizontal N.–S. temperature gradient decreases and is ultimately reversed in sign, from which it follows that the wind velocity generally will have its max. value at about the base of the stratosphere, as has been found to be the case. J. S. Di.

994. *Relation between Strength of the Trade Winds of the North Atlantic and Temperature in Europe.* **P. H. Gallé.** (K. Akad. Amsterdam, Proc. 18. pp. 1435–1448, 1916.)—In a former paper it was suggested that the effect of a change in the North Atlantic trade winds could be traced after two or three months in some hydrographical phenomena of Northern Europe, the action

taking place through the intermediary of the Gulf Stream [see Abs. 649 (1915)]. A further question arises as to whether the winter temperature of NW. Europe will not also be found to have a connection with trade-wind agencies. The problem is attacked by the method of correlation, coefficients being calculated between the winter temperature (Dec. to Feb.) at many stations in a comprehensive area which embraces Europe and Iceland, and the strength of the North Atlantic trades in different periods of the preceding summer. The 15 years 1899–1913 are used for the purpose. Taking Europe as a whole, it is found that the period May to Oct. for the trades gives the highest correlation with European winter temperatures, June to Nov. giving only slightly less. The values for the individual stations have been plotted on maps and lines of equal correlation drawn. It is found that positive departures from normal in the strength of the NE. trade are accompanied by positive departures of the winter temperature at places to the SE. of a line passing through the British Isles and Central Norway, and by negative temperature departures to the NW. of this line. The positive coefficients range up to 0·7, and the negative to −0·6. In considering what degree of accuracy could be obtained in forecasting the temperature of a coming winter from knowledge of the strength of the trades in the previous summer, the region which shows the highest correlation (Central Germany) is chosen, and the deviations from the normal of the two elements are plotted on the same diagram for 16 years. It is found that in 14 cases out of the 16 the deviations show the same sign, and thus it would have been possible in seven out of eight cases to make a good forecast about the sign of the departure of the coming winter temperature. The standard deviation of the temperature is 1·3° C., and making use of the trade-wind strength the error of estimate of the temperature will be 0·5° C.

J. S. Di.

995. *Solar Radiation at Arequipa.* **C. G. Abbot.** (Smithsonian Misc. Collection, 65. No. 9. Nature, 97. p. 410, July 13, 1916. Abstract.)—Measurements of the solar radiation have been made at Arequipa since 1912, and the results are discussed in special reference to solar variability and atmospheric transmission. The monthly mean values of radiation show a close connection with the variations of vapour pressure in the terrestrial atmosphere. C. P. B.

996. *The Melting of Snow.* **R. E. Horton.** (Monthly Weather Rev. 43. pp. 599–605, Dec., 1915.)—Describes experiments with melting snow under various conditions. Some of the conclusions are: (1) After a cold snap, when the lower layers of snow are at a temperature much below 32° F., the water resulting from surface melting percolates to a slight depth in the snow, and there freezes upon the snow crystals, forming stratification in the snow mass. (2) If a thaw occurs when there is snow at about 32° F., most of the water produced percolates down through the snow, part of the water adhering to the snow crystals as a capillary film. (3) When snow and water are in temperature equilibrium (32° F.), percolation and capillary action through the snow may take place in the same manner as the flow of water through porous soil. In this condition snow will support a column of water, which, in inches, is measured by 3 to 5 times the specific gravity of the snow. (4) The run-off lags behind the melting until nearly the whole snow mass is converted into slush. Meanwhile run-off proceeds slowly through capillary flow. Further melting breaks down the capillary action; the run-off then becomes rapid, and floods are produced. R. C.

997. *Periodic Disturbance of Level arising from the Load of Neighbouring Oceanic Tides.* **K. Terazawa.** (Roy. Soc., Phil. Trans. 217. pp. 35–50, July 12, 1916.)—In work on the lunar deflection of gravity, O. Hecker has pointed out that the force acting on the pendulum at Potsdam is a larger fraction of the moon's force when it acts towards the east or west than when it acts towards the north or south. Various explanations of this anomaly have been proposed: Love suggested that a possible cause may perhaps be found in the attraction of the tide wave in the North Atlantic; Michelsen has recently found a similar result; Larmor has suggested whether the excess-pressure of the tide in the North Atlantic would affect much the measurement of water-level at Chicago owing to the elastic depression of the earth's surface that it would produce. In the present paper the calculation is undertaken to ascertain to what extent the consideration of tilting of the ground is important for the explanation of this geodynamical discrepancy, on the assumption that the earth consists of elastic matter of uniform density and of uniform invariable elastic constants, and that the North Atlantic may be represented roughly as a circular basin and that the tide in it is uniform or else elliptic. The effect of tilting is found to be about three times as great as that of the attraction. As the tilting effect and the attraction effect of the tide wave are directly proportional to the height of the tide, the total effect oscillates in time in accordance with the law which the tide obeys. There is, in general, a difference in phase between the lunar and tidal effects, which is worthy of closer investigation. H. H. Ho.

998. *Dissymmetry of the Pacific.* **E. Belot.** (Comptes Rendus, 162. pp. 951–953, June 19, 1916.)—The existing proportions of land and water in the two hemispheres are analysed in connection with the theory of a primitive southern deluge, showing that many difficulties may be explained by this means. [See Abs. 1496 (1914).] C. P. B.

999. *Variations of Latitude and Earth Structure.* **F. Schlesinger.** (Am. Phil. Soc., Proc. 54. pp. 351–358, Oct.-Dec., 1915.)—A short summary is given of the history of latitude variation from its prediction as a motion of the axis of rotation by Euler in 1755, with a period of about 10 months, to the first indications of successful detection by Küstner in 1888, and its definite acceptance as an observable phenomenon in 1893. In the investigation of the interesting results obtained Chandler was able to trace the presence of the variations back to the time of Bradley in the middle of the eighteenth century. The observations made under the auspices of the International Geodetic Association have been carried out at six stations since 1899, and have attained such accuracy that the determined latitudes are reliable to 0·02″. Newcomb showed that the period of 10 months determined by Euler was on the assumption that the earth was rigid and unyielding, and that if the earth's rigidity was taken as similar to that of steel, the Eulerian period would be near 14 months, thus agreeing closely with observation. The amplitude of the term is usually about 0·27″, but has at times suddenly increased, and the question is under consideration whether such changes may be ascribed to earthquake phenomena. In addition to the Eulerian term, a smaller variation with an annual term is ascribed to seasonal and meteorological changes. C. P. B.

1000. *Photographic Latitude Determination.* **Ross.** (U.S. Coast and Geodetic Survey, Special Publ. No. 27. Nature, 97. p. 311, June 8, 1916.

Abstract.)—Details are given of a photographic zenith-tube instrument specially designed for the determination of latitude. The apparatus consists of a fixed vertical tube carrying a horizontal lens above a dish of mercury, with means provided for following the star images for prolonged exposures, and for reversal through 180°. Comparison with visual methods shows that no systematic differences are to be detected, and these first results are considered to confirm the reality of the Kimura term in the variation of latitude. C. P. B.

1001. *Study of Solar Vortices.* **C. Störmer.** (Astrophys. J. 43. pp. 347–402, June, 1916.)—In the study of the solar vortices shown on spectro-heliograms at the Mt. Wilson Observatory [Abs. 783 (1909)] certain resemblances were detected between the forms of the hydrogen flocculi and the curves showing the trajectories of air particles during terrestrial cyclones as found by Guldberg and Mohn in 1876. Starting then with the hypothesis that the motion of charged electric gas molecules takes place along such spirals, the resulting magnetic field was determined. A long analysis of the theory of such logarithmic spiral whirls is given, with many diagrams showing the resulting types from various assumptions. On the assumption that the Zeeman-effects observed are due to convection currents the values of the field become so great that it is difficult to explain the absence of the Stark-effect, and it is proposed next to examine the hypothesis of galvanic currents circulating round sun-spots. Attention is drawn to the importance of a collateral study of the phenomena of terrestrial auroræ.
C. P. B.

1002. *Localisation of the Epicentre of an Earthquake from Observations of a Single Seismic Station.* **B. Galitzine.** (Comptes Rendus, 162. pp. 878–880, June 5, 1916.)—The author's method was described by him in 1910. He employs two aperiodic horizontal pendulums, with galvanometric registration, installed at right angles to each other. It is possible to determine the azimuth α of the epicentre by measuring the amplitudes of displacement of the luminous point that registers the outset of the first phase P, that is to say, of the moment of arrival of the first longitudinal seismic waves. If L represents the reduced length of the pendulum, k the coefficient for the galvanometric registration, determining the sensitiveness of the apparatus, and A_1 the length of the optic ray for photographic purposes, then $C = \pi L/kA_1$. For seismography this represents a characteristic constant.

Again, if the two pendulums and the two corresponding galvanometers are installed at the limit of aperiodicity, and all possess the same period of oscillation when damping is suppressed, then the azimuth α is easily calculated from the formula, $\tan \alpha = C_E\gamma_E/C_N\gamma_N$, where γ_E and γ_N are the amplitudes of the same maximum for the seismograms at the outset of the plane P for the components E.–W. and N.–S., and C_E and C_N the values of the constants of the corresponding seismographs. The author then enters upon general considerations.

The apparatus is installed at Pulkowa and the other Russian seismic observatories of the first class. E. O. W.

1003. *Localisation of the Epicentre of an Earthquake.* **B. Galitzine.** (Comptes Rendus, 162. pp. 954–956, June 19, 1916.)—The author notes the fact that in some quarters his method [see preceding Abs.] is mistrusted. To substantiate his claim for accuracy data have been collected of the total number of earthquakes (strong or feeble) observed at Pulkowa during 4 years, and the

number of times it has been possible to determine α and then, while knowing Δ, the epicentral distance, to localise the epicentre. They are as follows :—

Year.	Number of Earthquakes.	Number of Determinations of α.	Percentage of whole.
1912	671	137	20
1913	576	103	18
1914	475	72	15
1915	454	88	19

Considering that Pulkowa is far from any seismic region and that the number of cases in which α has been there determined, the author regards the evidence as much in his favour, and shows how great a measure of sensitiveness has been reached with his apparatus.

Date.	Epicentral Region.	Station.	ϕ.	λ.
1914				
5 March	Armenia	P.	37° N.	40° E.
		E.	39	42
		Ts.	38	41
		Tf.	37	41
14 March	Japan	P.	39° N.	140° E.
		E.	40	141
		I.	39	138
		Ts.	40	141
		M.	40	140
26 May	Near New Guinea	P.	0° S.	139° E.
		E.	1	141
		I.	1	143
		Ts.	3	140
25 Juue	Sumatra	P.	2° S.	100° E.
		E.	2	101
		I.	0	104
		Ts.	3	101
4 July	At the SE. of Japan	P.	20° N.	138° E.
		E.	20	137
		Ts.	20	137
4 Aug.	Tian-Chan.	P.	45° N.	93° E.
		E.	45	93
		I.	43	91
		Ts.	45	93
		Tf.	43	92
11 Oct.	Bay of Bengal	P.	13° N.	95° E.
		E.	13	95
		Tf.	13	93
17 Oct.	Greece	P.	39° N.	23° E.
		E.	38	23
		Ts.	38	23
		Tf.	38	22
		M.	39	22
1915				
5 Jan.	Near Formosa	P.	28° N.	122° E.
		E.	28	122
		I.	28	122
13 Jan.	Central Italy, Avezzano	P.	42° N.	14° E.
		E.	43	14
		I.	42	13
		Tf.	42	13
10 March	Celebes I.	P.	0° S.	120° E.
		E.	1	120
		I.	1° N.	120
		Ts.	3° S.	121
18 March	Abyssinia	P.	16° N.	37° E.
		E.	16	40
		Ts.	17	39
		M.	16	38
4 June	Japan	P.	41° N.	144° E.
		E.	42	144
		Tf.	40	147
22 June	Philippines	P.	11° N.	120° E.
		E.	11	123
		Ts.	9	122
3 Aug.	New Guinea	P.	1° S.	131° E.
		E.	2	134
7 Aug.	Ionian Sea	P.	40° N.	19° E.
		E.	39	21
		Tf.	39	20
11 Aug.	Ionian Sea	P.	40° N.	18° E.
		E.	38	20
		Tf.	49	19

In the above table particular cases of much interest are quoted. In 3 years the Russian Commission of Seismology has undertaken a complete reorganisation which is nearly terminated. The observatories of the first class are Tiflis (Tf.), Taskart (Ts.), Irkutsk (I.), Ekaterinburg (E.), and Makeevka (M.). These are modelled on Pulkowa.

In the table ϕ represents the lat. and λ the long. (Greenwich) of the corresponding epicentre. E. O. W.

1004. *Shifts of Solar Spectrum Lines from Centre to Limb.* **J. Evershed and T. Royds.** (Kodaikanal Observatory Bull. 49. Nature, 97. p. 388, July 6, 1916. Abstract.)—The variations of the wave-lengths of certain iron lines have been studied in detail over different portions of the sun's disc, and they begin to be measurable at about 0·3 radius from the centre. The authors favour the view that the shifts are due to line-of-sight motion rather than to anomalous dispersion. C. P. B.

1005. *Nature of Solar Corona.* **J. W. Nicholson.** (Observatory, No. 502, pp. 308–312, July, 1916.)—A more complete account is given of the numerical relations existing between the wave-lengths of the spectrum lines of the solar corona, this having been rendered possible by the discovery of a new radiation at the eclipse of Aug. 1914, which provides a useful link between otherwise isolated lines. The fundamental atom considered is that of the simple ring system of Rutherford, having a radius of about 10^{-8} cm., with electrons of radius about 10^{-13} cm., and a central nucleus still smaller. It is shown that the wave-length of the resulting spectrum lines as computed from the analysis of such a vibrating system are so closely coincident with the lines determined from observation that little doubt is possible as to the reality of the system. The striking characteristic of the result is the recognition of a number of series, in which the lines of each series are such that the cube roots of the wave-lengths form an arithmetic series, and the different series are also related to each other by definite ratios. In the summary showing the electrical conditions producing such lines, attention is drawn to the fact that all the strong coronal lines are due to negatively charged atoms. C. P. B.

1006. *Anomalous Dispersion in the Sun.* **S. Albrecht.** (Observatory, No. 502. pp. 314–317, July, 1916.)—In reference to the small displacements produced in spectra which have been by some ascribed to anomalous dispersion, by others to mutual repulsion between spectrum lines in close proximity [Abs. 1220 (1915)], it is now discussed whether two conditions may not be operative, according to whether the sources of vibration are independent in the sense of being due to different elements, or related by being due to the same element. Iron is the element examined specially, and it is found that the displacement when both components are due to iron is only about half as great as when the lines are due to two different elements. The fact that the displacement is not reduced to zero is explained by the fact that even two solar lines due to the same element are not invariably connected in the molecule, but are in part of independent origin. C. P. B.

1007. *Determination of Solar Motion from Radial Velocities.* **C. D. Perrine.** (Astrophys. J. 43. pp. 286–294, May, 1916.)—Examination of the results of radial-velocity determinations show that after the elimination of the solar motion there is in general a small residual which has been designated as the K term. After thus eliminating the solar motion from the stars of each spectral class, the residuals are found to be different for the galactic and non-galactic regions, the differences being large and apparently systematic. Other large differences of an apparently systematic nature have been found in large areas of the sky, which add to the suspicion of irregularity in the tendency of motions in different directions. From this lack of uniformity it appears possible that the peculiarities observed are other than motions. C. P. B.

1008. *Chemical Origin of Solar Radiation.* **Briner.** (Rev. Générale des Sciences, No. 9, 1916. Nature, 97. p. 349, June 22, 1916. Abstract.)—

While agreeing with the conclusion of Arrhenius that radio-active changes are insufficient to account for the origin of solar energy, the author shows that both endothermic and exothermic reactions involving either elementary or compound substances are also insufficient. It is then considered that if the interior of the sun is largely composed of matter in a proto-atomic state, a possible source of solar energy would be available by the successive modifications resulting in the formation of the chemical elements. C. P. B.

1009. *Refinements in Spectrographic Measurements.* **H. H. Plaskett.** (Roy. Astron. Soc. of Canada, J. 1a. No. 5. Nature, 97. p. 451, July 27, 1916. Abstract.)—An investigation has been made of the differences found by different observers in the measurement of the same spectrograms, with special reference to the solar rotation velocity. The chief source of the differences is attributed to the attitude of the observer, in the sense of his being under the influence of any prepossessions or otherwise. It is concluded that the highest accuracy can only be attained by replacing differential measures by determinations of changes of wave-length by means of standard absorption lines, and work of this type has already been started at Ottawa. C. P. B.

1010. *Thermoelectric Photographic Photometry.* **H. T. Stetson.** (Astrophys. J. 43. pp. 253–285, May, 1916.)—As the present methods connected with selenium and photoelectric cells for stellar photometry are only applicable to stars of moderate brightness, an attempt has been made to develop a physical method of measuring the images on photographic plates. After experiments with various instruments, it was decided to use a thermopile, placed so as to receive light from a constant light-source, in the path of which could be placed the star images, thus stopping amounts of energy varying with the magnitude of the star. In the thermopile it was decided to use a bismuth-silver element of symmetrical design, having a circular receiving surface 5 mm. in diam. and a resistance of 2·3 ohms. Tests showed this to have a sensitiveness of 1 microwatt per 0·18 microvolt, and a period of only a few seconds. The element was satisfactorily protected from external heat influence by enclosure in non-conducting material, provision for setting being made by the use of a small mirror and reading telescope. Special attention is drawn to the diaphragm used for limiting the field to the particular star image under examination. The method is also being applied to the measurement of stellar spectra photographs. C. P. B.

1011. *Thermoelectric Photographic Photometry.* **H. T. Stetson.** (Astrophys. J. 43. pp. 325–340, June, 1916.)—In a previous paper [see preceding Abs.] the author described an instrument, containing a delicate thermopile as receiver, by means of which the magnitudes of stars may be determined from either focal or extra-focal plates by purely physical means. The apparatus has also been adapted to the measurement of spectral intensities, and employed in the investigation of objective-prism plates of B-type stars. A study of the eclipsing variable U Cephei indicates the presence of light-changes not explained on the eclipse theory alone, and revealing a suspected variability in the comparison star. It is expected to attain a greater degree of accuracy from the measurements by thermopile than by diameters. The principal sources of error appear to be the changing atmospheric conditions during the exposure at the telescope and irregularities in the photographic plate. C. P. B.

1012. *Monochromatic Photographs of Jupiter and Saturn.* **R. W. Wood.** (Mt. Wilson Solar Observatory, Contrib. No. 113. Astrophys. J. 43. pp. 310–319, May, 1916.)—The interesting results obtained by the use of monochromatic transmission filters in photographing the moon [Abs. 1655 (1912)] led the author to extend the inquiry to the planets Jupiter and Saturn. This was carried out at the Mt. Wilson Observatory with the 60-in. reflector, the photographs being made with four types of colour transmission: infra-red, yellow, violet, and ultra-violet. For the ultra-violet filter a cell of bromine vapour 5 cm. thick was used, in conjunction with a thin cell 1 or 2 mm. thick containing potassium chromate. Reproductions are given showing the differences in the markings on the planets. On Jupiter the dark belts are scarcely visible on the infra-red plates, while the pictures made with violet light show them in the greatest contrast.

In the case of Saturn it is seen that the contrast between the inner and outer ring becomes markedly less as the wave-length of the effective light is decreased. C. P. B.

1013. *Observations of Mars at Flagstaff (Arizona).* **G. Hall-Hamilton.** (Comptes Rendus, 162. pp. 871–872, June 5, 1916.)—A drawing is given showing details measured from photographs taken at the Lowell Observatory, the author giving great praise to the quality of the observing conditions, and to the certainty of recognising details on the planet which have been consistently observed during the past 15 or 20 years. C. P. B.

1014. *Motion of Nuclei of Comet Taylor* (1915*c*). **H. Thiele.** (Astron. Nachr. No. 4846. Nature, 97. p. 388, July 6, 1916. Abstract.)—From a series of measures of the nuclei of this comet, made at Bergedorf between Feb. 19 and April 3, the distance showed little change, but the position angle varied considerably, giving a period of about 30 days. C. P. B.

1015. *Elements and Ephemeris of Comet Taylor* (1915*c*). **H. M. Jeffers** and **F. J. Neubauer.** (Lick Observatory, Bull. 9. [No. 281], pp. 12–13, 1916.)—The elements given are derived from normal places observed on 1915 Dec. 8, 1916 Jan. 8 and April 5. An ephemeris is given extending from 1916 May 26 to Aug. 26. With the exception of the longitude of the node, the elements of this comet are in general agreement with those of Comet Daniel (1909*e*). C. P. B.

1016. *Elements and Ephemeris of Comet Wolf* (1916*b*). **R. T. Crawford** and **D. Alter.** (Lick Observatory, Bull. 9. [No. 282], pp. 15–16, 1916. Nature, 97. p. 410, July 13, 1916. Abstract.)—This comet was discovered on 1916 April 27, and is interesting from the fact that its geocentric distance was then greater than that of any other comet at discovery. Elements are derived from three observations on 1916 April 24, May 10, and May 23, and an ephemeris computed for the interval 1916 June 2 to Aug. 29. It is concluded that this comet is not identical with Wolf's periodic comet, 1884 III. C. P. B.

1017. *Variable Stellar Spectra of Cepheid Type.* **H. Shapley.** (Nat. Acad. Sci., Proc. 2. p. 208, 1916. Nature, 97. p. 428, July 20, 1916. Abstract.)—From a study of 150 spectrograms of 11 Cepheid variables taken at the Mt. Wilson Observatory it is found that the periods vary from 9 hours to 27 days, and that the details of the spectra change with the phase. These spectral changes were so closely related to the changes in brightness that it was found they exhibited definite alterations from one spectral class to another, the maximum brilliancy

corresponding to a higher stage in the spectral sequence than the minimum. It is thus inferred that all Cepheids, including those of the cluster type, vary periodically in spectral class, as well as in magnitude and radial velocity. C. P. B.

1018. *Orbit of Ursa-Major Moving Cluster.* **L. Courvoisier.** (Astron. Nachr. No. 4832. Observatory, No. 502. p. 318, July, 1916.)—A special study of this system has been made with the view of detecting an orbital motion under the general attraction of the stellar system. It is stated that the stars are arranged approximately along two parallel straight lines about 18 parsecs apart, these lines being inclined at about 56° to the galactic plane, the orbital motion being nearly parallel to the planes. If the orbit is circular the period of revolution comes to be about 180 million years. C. P. B.

1019. *Orbit of Spectroscopic Binary B.D.* 78° 412. **O. J. Lee.** (Astrophys. J. 43. pp. 320–324, May, 1916.)—This interesting system is of spectrum type A_5 and magnitude 5·12. The orbit is derived from spectrograms taken during the period 1913 Jan. 21 to 1915 July 5, a period of 895 days corresponding to 705 periods of the binary. The adopted period is 1·271 days. C. P. B.

1020. *Spectrum of Nova Geminorum No.* 2. **W. S. Adams and Pease.** (Astron. Soc. of the Pacific, Publ. No. 163. Nature, 97. p. 311, June 8, 1916. Abstract.)—From a photograph of the spectrum of this object taken at Mt. Wilson on the nights of Feb. 12 and 13, 1916, with a total exposure of 9 hours, it is found that the characteristic Wolf-Rayet features are still predominant. The continuous spectrum is strong, with bright hydrogen bands and a bright band at λ4686. C. P. B.

1021. *Kinetic Energy of a Star-cluster.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 76. pp. 525–528, April, 1916.)—Proof is given in full of the interesting analytical result that in any star-cluster in a steady state the internal kinetic energy is one-half the exhaustion of potential energy. C. P. B.

1022. *Stereoscopic Spectroheliograms.* **G. E. Hale.** (Nature, 97. p. 249, May 18, 1916.)—From a pair of photographs of the hydrogen flocculi in H_α light taken with the new spectroheliograph at Mt. Wilson on Aug. 7, 1915, a stereogram has been prepared showing the sun's surface near the west limb, with a large spot group surrounded by flocculi. The time interval between the two exposures was 7 mins. Although due allowance must be made for surface changes during the interval, it is thought that the method may in many cases prove valuable for deciding questions of relative level in the solar atmosphere. C. P. B.

1023. *Structure of the Galaxy.* **C. V. L. Charlier.** (Comptes Rendus, 162. pp. 872–875, June 5, 1916. Roy. Astron. Soc., M.N. 76. pp. 589–592, May, 1916.)—The note is a short summary of the results of an examination of the distribution of the stars of spectral class B. Diagrams are given showing the structure along various lines of sight. The nearest star of type B to the sun is α Eridani, being found to be only 4 siriometres distant, while the most distant body of the type is about 250 siriometres. (One siriometre is equal to 10^6 times the distance of the sun from the earth, 93×10^6 miles.) C. P. B.

LIGHT.

1024. *A Precision Shutter-testing Instrument.* **P. G. Nutting.** (Phot. J. 56. pp. 172–176, June, 1916.)—A great number of instruments have been designed for the testing of photographic shutters, some of the instruments being intended to determine the total period during which the shutter is open, while in others an attempt is made to measure the effective area of the opening at different periods of the exposure. The methods of Abney and of Campbell and Smith are here briefly described. The best method of testing a photographic shutter would be to take a number of photographs of the shutter through its period of operation, the time of exposure of each photograph being small in comparison with the rate of movement of the shutter, and if these instantaneous photographs can be taken at known intervals, then all the data required for calculating both the efficiency and the duration of the exposure of the shutter are obtained. In the apparatus described, the illuminating beam is reflected from a lightly mounted Al crown on which are placed 20 small plane mirrors held vertically on the face of the crown. This crown of mirrors is rotated at a very constant speed by means of a Leeds-Northrup governed motor making 1200 revs. per min. The motor is governed by means of a centrifugal governor, which makes and breaks the current, the system being very simple and accurate in operation: by attachment of a chronograph the speed of the motor is found to be constant with 50 % variation in load or 5 % in line voltage to within 1/10 %. By suitable gearings the crown is rotated at 50 revs. per sec. Since the crown carries 20 mirrors, we have 1000 interruptions of the beam per sec., and this frequency does not vary by a thousandth of itself. By increasing the number of mirrors from 20 to 50 and doubling their speed of rotation, it would be quite practicable to increase the frequency to 5000 per sec., but the lower frequency of a thousand is found to be the most suitable for general testing. The crown is illuminated by an arc lamp in a small projection lantern, the condenser of the lantern focusing an image of the arc crater at the mirror surface. The duration of each flash is determined by the angular width of the light beam at the lantern condenser, as since the beam at this point is limited by a vertical slide 2 mm. wide, the width of the beam as it flashes by reflection past the shutter opening is about 1/30 of the distance between the flashes, so that each exposure is about 1/30,000 sec. The reflected beam falls on a simple lens behind which the shutter to be tested is held in a universal iris holder, and an image of the shutter is then formed by a small camera lens of 90 mm. focal length on the rim of an Al wheel 12 in. diam., around which can be fastened a band of negative kinematograph film. Examples of shutter speed testing are given. A. E. G.

1025. *Optical Projecting Lanterns.* **J. B. Taylor.** (Am. Illum. Eng. Soc., Trans. 11. pp. 414–427; Disc., 427–435, May 1, 1916.)—The early part of the paper summarises the fundamental principles of optical projection, and the author also describes the means by which solid objects may be projected. Lantern slides show up sufficiently well if the screen-illumination of the whites is 0·5 candle-ft., but 10 or even 20 times this illumination is sometimes used. For moving pictures a somewhat brighter screen is desirable, and the illumination should be at least twice as great. Translucent and aluminium

screens are discussed ; such surfaces, while greatly increasing the brightness of the image seen by those directly facing the picture, diminish the effect as seen obliquely, and are apt to give rise to irregularities. In a theatre, time should be allowed for the eyes of the audience to become accommodated to the darkness before films are shown, and bright spots of light round doors and windows, which distract the eye, should be avoided. The use of a water-cell to absorb heat and avoid cracking of slides or films is regarded as essential. In the *discussion*, reference is made to the Leitz combined projecting apparatus, which can be used for ordinary lantern work, moving pictures, microscope projection, and the projection of solid objects. For microscope projection great flexibility and range of magnification is needed. In dealing with solid objects only about 3 % of the diffusely projected light goes through the objective. **H. Gage** gave some confirmatory figures for the brightness of the screen. For lantern-slides in a dark room 2·5 candle-ft. is sufficient, and 5 candle-ft. ample. With stained films much higher values are needed ; for example, 25 candle-ft. with blue material. **L. C. Porter** discussed the conditions in which electric glow-lamps may be used for projection ; such lamps are already used for small projectors, and will shortly answer for larger work where 25-amp. arcs are used. **M. Luckiesh** suggested that the speed required to eliminate flicker is a function of the screen-illumination, which should therefore be closely studied. J. S. D.

1026. *Distribution of Energy in the Visible Spectrum of an Acetylene Flame.* **W. W. Coblentz** and **W. B. Emerson.** (Bureau of Standards, Bull. pp. 355–364, 1916 [Sci. Papers No. 279].)—In a previous paper [Abs. 142 (1912)], data were given of the spectral energy distribution of a flat acetylene flame radiating edgewise into the slit of a mirror spectrometer. The data given in the present paper refer to a cylindrical acetylene flame, produced by a single-jet "Crescent *Aero*" burner, consuming 1/4 cub. ft. of gas per hour, the gas pressure at the outlet being 7·5 cm. of water. The central portion of the flame (35 mm. high and 3 mm. thick) was used. In the region of the spectrum extending from the yellow to the violet the spectral energy distribution of all the flames examined appears to be the same, within the limits of observation. On the other hand, in the region extending from the red toward the long wave-lengths, the emissivity is greatly affected by the variation in thickness of the radiating layer of incandescent particles in the flame. Hence, in and beyond the red part of the spectrum the data apply only to cylindrical flames which are operated under specified conditions. A comparison of the "Bray" burner used by Nutting in his work on the visibility of radiation with the "Crescent *Aero*" burner, showed the energy distribution in the flames to be the same throughout the visible spectrum to 0·70 μ, where the former begins to increase in emissivity. The paper is illustrated with tables and graphs. A. W.

1027. *Dispersion and Absorption of Thin Metal Layers.* **B. Pogány.** (Phys. Zeits. 17. pp. 251–259, June 15, 1916.)—In a previous paper [Abs. 1676 (1914)] measurements of the electrical conductivity and optical properties of thin layers of Pt, Pd, Au, and Ag were given. The results for gold were particularly interesting, as the index of absorption of thin layers of gold as a function of the thickness of the layer possesses a maximum. This result cannot be explained by Planck's theory of absorption and dispersion by thin metal layers. Further measurements, carried out in a manner different from the earlier ones, confirm the results already obtained. A description is

given of these later experiments. In the second part of the paper it is shown that besides the usual assumptions of Planck's theory it is necessary to assume that throughout a thin metal layer the conducting electrons are bound by quasi-elastic forces; it is then possible to explain both the optical behaviour and the phenomena of electrical conductivity in thin metal layers.

A. W.

1028. *Ruling and Performance of a Ten-inch Diffraction Grating.* **A. A. Michelson.** (Frank. Inst., J. 181. pp. 785–789, June, 1916.)—Special precautions have been taken with the construction of a new ruling machine designed for making diffraction gratings with ruled surface 14 in. long. The corrections of the residual errors were determined by means of interferometer mirrors mounted on the instrument. Reproduction is given of a photograph of the green mercury line $\lambda 5461$, taken with a 10-in. grating in the 6th order; the negative shows a resolving power of about 600,000, very nearly the full theoretical value. Attention is drawn to the possibility of producing gratings by means of the direct action of light waves from a homogeneous source without the intervention of screws or other instrumental apparatus.

C. P. B.

1029. *New Method for Enlarging Photographs without the Use of a Lens.* **A. J. Lotka.** (Phys. Rev. 7. pp. 660–662, June, 1916.)—The method consists in moving the negative to be enlarged past a narrow slit source of light, and at the same time moving a sensitive plate under the negative at a speed equal to some constant multiple (n) of the speed of the negative. On development of the sensitive plate a positive transparency is obtained, in which all lines of the original negative which were parallel to the slit during the exposure are unaltered, while all lines at right angles to the slit are magnified in the ratio $n:1$. This positive is subsequently subjected to a repetition of the process practised on the original negative, but with the motion now at right angles to the lines drawn out n-fold in the first operation. The result of the second operation is a negative geometrically similar to the original but with the linear dimensions enlarged n times, or the area n^2 times. The apparatus employed for carrying out the process has been constructed on exceedingly simple lines with the use of material readily obtainable on the market, *e.g.* when the ratio n of the velocities is 2 a simple contrivance in accordance with the principle of the single movable pulley enables the relative motion to be obtained and is secured by the simple expedient shown diagrammatically in the original. Among the advantages which the new method presents is uniformity of illumination over the entire field; geometric similarity to the original of the image produced, *i.e.* absence of distortion such as spherical aberration introduces; compactness and simplicity of apparatus; replacement of lens by a simple slit, and hence low cost of the apparatus. The process necessitates two successive exposures, but this is true also of the ordinary method when a negative is to be prepared from a negative. It is shown that the limiting separation (d) which the apparatus will effect is given by the formula $d=(n-1)n/s$, in which $s=$ diam. of slit and $n=$ degree of magnification. Thus, for example, for $n=2$ we have $d=s/2$, and a comparatively coarse slit 1/100 in. wide will still separate points just a little over 1/200 in. apart.

A. E. G.

1030. *Colour Filter for Spectrum Photography.* **M. Luckiesh.** (Astrophys. J. 43. pp. 302–309, May, 1916.)—To compensate for the varying plate sensitiveness to different colours the author first exposes one of the plates to

the spectrum given by a continuous light source, and after development this plate is placed in front of subsequent plates so that the spectra pass through the negative of the continuous spectrum. This will ensure an automatic screening of those parts of the spectrum which are most strongly impressed on the plate, thus producing a more even band of photographic action. Curves are given showing the action on plates of various makers, with grating and prism spectrographs. C. P. B.

1031. *Minimum Deviation in Prism.* **V. G. Cavallaro.** (N. Cimento, 11. pp. 221–228, March–April, 1916.)—A simple and direct proof, without mathematics beyond trigonometry, of the law of minimum deviation in a prism. A. D.

1032. *Theory of Colour-vision.* **R. A. Houstoun.** (Roy. Soc., Proc. 92. pp. 424–432, July 1, 1916.)—The conception of primary colours and the Young-Helmholtz theory of colour-vision appears to be based mainly upon experiments on the mixing of pigments. The author seeks to show how the facts of colour-mixing can be explained by a mathematical formulation of the Edridge-Green theory of colour vision.

Starting from the luminosity curve for the spectrum as seen by the normal eye and verified by Ives and Nutting, the author develops some equations by which the shape of this curve, and its alteration at diminished intensity can be explained. In order to explain physically the Purkinje-effect he suggests that the vibrators on the retina can be regarded as embedded in a yellow medium. At low intensities the energy is absorbed near the surface of this medium : at high intensities most of the vibrators near the surface will become bleached. Consequently at high intensities the maximum is shifted towards the yellow. There is no decided evidence in favour of the existence of three distinct sets of vibrators in the eye. The vibrators may be assumed to set up waves which are carried to the brain, on the analogy of the telephone. The vibrator, however, does not reproduce the wave accurately, and even if monochromatic light impinges on the eye the wave transmitted along the nerve may not be monochromatic. In order to explain the apparent trichromatism of ordinary sensations it is necessary to assume that the colour-perceiving centre is imperfectly developed, so that the luminosity curve is made up of the juxtaposition of three rectangles. J. S. D.

1033. *Absence of Purkinje-effect in the Fovea of the Eye.* **L. T. Troland.** (Frank. Inst., J. 182. pp. 111–112, July, 1916.)—In studying this effect the author used a field of 1° diameter with a central red belt 0·34° wide, illuminated by light of wave-length 654–687 $\mu\mu$. The adjacent area was illuminated with light of wave-length 469–481 $\mu\mu$. In the centre of the field was a luminous fixation spot, just bright enough to be visible to the dark-adapted eye. This served to maintain a steady direction of vision. The observer was asked to determine the points at which (1) the red was slightly brighter than the blue, and (2) the two were of equal brightness. This experiment was carried out at 50 photons. (One photon is an illumination of the retina corresponding with a stimulus surface-brightness of 1 candle per sq. m., and an effective pupillary aperture of 1 mm.^{2}). The subject was next given 30 minutes' complete dark adaptation, and he was then asked to repeat his observations with the absolute brightness of both fields reduced to 1/32 of the former values. In four separate experiments conducted in this way the author failed to detect any sign of the Purkinje-effect. J. S. D.

1034. *Effect of Temperature upon the Absorption Spectrum of a Synthetic Ruby.* **K. S. Gibson.** (Phys. Rev. 8. pp. 38–47, July, 1916.)—The effect of temperature upon the absorption spectrum of a synthetic ruby has been studied, a Lummer-Brodhun spectrophotometer being used. Curves are given showing how the percentage transmission and the coefficient of absorption vary with the wave-length at different temperatures. The wave-lengths of the various lines and bands in the absorption spectrum have been determined, and the values obtained agree closely with those obtained by other investigators. A relation has been found between the wave-length λ and the absolute temperature T for an absorption doublet in the red part of the spectrum. This relation is of the form $\lambda = a + be^{kT}$, where a, b, and k are constants which may be determined graphically. [See Abs. 1409 (1915).]

A. W.

1035. *Interferences of the Direct Spectra of Two Gratings.* **C. Barus.** (Phys. Rev. 7. pp. 587–598, June, 1916. Abstract of Report to Carnegie Inst. of Washington.)—The chief purpose of the work described in the present paper is the search for phenomena similar to those recently discussed [Abs. 270 (1916)], but in which the two spectra brought to interference are not inverted relative to each other. The apparatus used was similar to that employed previously, two plane transmission gratings being mounted parallel to one another, the distance apart being controlled by a micrometer screw. Light from a collimator with slit is sent through the two gratings, observations being made at the other side with a telescope or a single ocular. The adjustments in the case of white light are simple, and the interferences usually very pronounced, large, and striking. Brilliant spectra, channelled with vertical narrow black lines, are easily obtained when the longitudinal axes are placed accurately in coincidence. If the gratings are quite identical the sodium lines will also be in coincidence. Otherwise the two doublets D_1D_2 and $D_1'D_2'$ of the two spectra (nearly identical in all their parts and in the same direction) are placed in coincidence by rotating either grating around a vertical axis. Thereupon the strong fringes will usually appear for all distances e between the gratings less than 2 cm. These fringes are nearly equidistant, vertical, and they intersect the whole spectrum transversely. They are not complicated with other fringes, as in the experiments previously described. They increase in size till a single shadow fills the field of view, in proportion as the distance e is made smaller and smaller to the limit of complete contact. Various particular cases are dealt with. (1) *White light. Coloured fringes.*—The two sodium doublets seen in the arc spectrum are usually equally brilliant, and but one set of strong fringes is present in the field of the telescope. If both gratings are rotated, changing the angle of incidence from 0° to i°, the fringes disappear from the principal focal plane, but reappear strongly in another focal plane. In such a case the D lines are no longer superposed. Introducing a plate of glass between the gratings produces an enlargement of the fringes, and a slight rotation of the slit round the axis of the collimator rotates the fringes in the opposite direction to the sodium lines. (2) *Homogeneous light. Wide slit. Transverse axes coincident.*—If there is no colour difference, fringes of the same kind will be seen in the telescope on widening the slit indefinitely. Accurate adjustments are again necessary if strong fringes are to appear in the principal focus. If the sodium lines are not superposed the fringes may still be seen, but they are not in the principal focal plane, and the new focal plane changes continunlly as the fringes grow in size. (3) *Homogeneous light. Fine slit. Transverse*

axes not coincident.—To obtain this group of interferences, the two sodium lines from a very fine slit are thrown slightly out of coincidence, by not more than the D_1D_2 distance. In the principal focal plane these doublets are seen sharply, while if the ocular is moved sufficiently forward or backward an interesting set of fringes appears which resemble Fresnel's fringes for two virtual slits. These fringes may be seen, however, on both sides of the focal plane, and increase in size with the distance of the plane of observation from the principal focal plane. (4) *Homogeneous light. Slit and collimator removed.*—The fringes observed in this case are similar to those with a wide slit.

All the different types are discussed at some length, and the question of the bearing the present experiments have on the reversed spectra is also dealt with. A. W.

1036. *Banded Spectra in Electric Furnace.* **A. S. King.** (Mt. Wilson Solar Observatory, Contrib. No. 114. Astrophys. J. 43. pp. 341–346, June, 1916.)—Sun-spot spectrum is largely made up of the banded spectra of titanium oxide, magnesium hydride, and calcium hydride, and the present paper gives the results of a determination of the laboratory conditions necessary to give the structure in its purest form. In the case of Ti it was already known that the electric furnace *in vacuo* did not produce the band spectrum, and admission of air to half an atmosphere also failed to show the bands. On introducing a powerful blast of air through the carbon resistance tube the bands came out with great distinctness, the line spectrum of Ti being practically suppressed. This was repeated with pure oxygen from a cylinder, with the same result. No material alteration of temperature appeared to be produced by the oxygen, the temperature of the operation being about 2300° C. A distinct difference of gradation of intensity was found in the furnace spectrum compared with that of the arc, the bands of the red end being relatively stronger in the furnace.

In the cases of magnesium and calcium it is clearly indicated that the band spectrum is specially prominent in an atmosphere of hydrogen, it being also noted that the structure is best about 2200° rather than at 2500° C.

C. P. B.

1037. *Distribution of Intensity in Broadened Spectrum Lines.* **J. W. Nicholson** and **T. R. Merton.** (Roy. Soc., Phil. Trans. 216. pp. 459–488, June 28, 1916.)—In a previous paper [Abs. 678 (1916)] a method of investigating the distribution of intensity in broadened spectrum lines was described, and it was shown that the results obtained for the hydrogen lines H_α, H_β, and H_γ were qualitatively in accordance with the intensity distribution to be expected on the view that the electric field of neighbouring atoms was responsible for the broadening. The present investigation is concerned with the quantitative determination of intensity in broadened spectrum lines, with the view of throwing some further light on the nature of the broadening and the circumstances which control it. Particulars are given of the method employed with the neutral wedge used to obtain the wedge-shaped image of the broadened lines. In making measurements of the images, enlargements were made through a ruled process screen, the resulting image thus consisting of fine black dots on a white ground. In this way measurements may be easily made by pricking out the last dot visible at a large number of points on the wedge, and subsequently drawing a curve through these points. It is believed that this method has almost entirely eliminated the personal error in picking out points of equal density. The line H_α has been quanti-

tatively investigated in this way, and qualitative observations have been made of other lines of H, He, and Li. The results of the investigation are as follows:—(1) The intensity distribution of lines, broadened by condensed discharges and at high pressures, does not follow the well-known probability law, which is known to obtain under certain specified conditions. (2) The broadening of H_α is symmetrical. (3) The most general characteristic of all the curves obtained is that their curvature is away from the axis perpendicular to the wave-length scale. It is shown that even in the case of a simple curve, such as that found for H_α, this is inconsistent with the view that a single component is involved. (4) The existence of more than one component is in accordance with the view that the electrical resolution of the lines is the origin of their broadening. (5) On the supposition of several components, symmetrically distributed about the centre, the only general law consistent with the distribution of curvature is that of a sum of linear exponential terms, one for each component. (6) It is shown that under these circumstances discontinuities in the slope of the curves must occur. The discontinuities which have been found in the curve for H_α are in quantitative accordance with those to be expected from the available data with respect to the electrical resolution. (7) Qualitative observations of H_β, H_γ, and the diffuse series of He and Li confirm the view that electrical resolution is the principal cause of the phenomena. (8) A discussion of further applications of the method is given. A. W.

1038. *Rotation of Interference Fringes in Reversed and Non-reversed Spectra.* **C. Barus.** (Am. J. Sci. 42. pp. 63–73, July, 1916.)—A continuation of previous work [Abs. 71, 776, and 1035 (1916)]. This paper gives a theoretical explanation of various experimental results previously dealt with. A. W.

1039. *Ratio between the Zeeman and Pressure Effects in the Spectrum of Nickel.* **T. van Lohuizen.** (K. Akad. Amsterdam, Proc. 18. No. 8. pp. 1309–1322, 1916.)—A comparison of these two effects for Fe, Cr, and Ti has been previously made by King [Abs. 1244 (1910)]. In the present discussion of the Ni spectrum the results of Miss Graftdijk for the magnetic decompositions have been employed, those of Bilham for the spark-spectrum and those of Duffield for the arc-spectrum pressure shifts. From these results it appears that simple proportionality between the two effects does not exist. Following the classification of Gale and Adams, the lines are divided into five groups. A study of the ratio of the two effects shows that the distinction of the different groups gives as pronounced results as in the investigation of the pressure effect alone. For the Groups I and II the ratio is greatest, while Group V is characterised by a very small ratio. Though the Groups I and II show great agreement, so that Bilham feels inclined to combine them into a single group, in the comparison of the two effects the difference is still considerable, and since a sufficient number of observations was here available, it is probable that the observed difference is a real one. The greatest differences were found in Group IV. The results obtained here point to the fact that these lines of this group (to which belong all so-called enhanced lines) are sensitive in very different degrees to the different ways in which the pressure effect has been determined. As to the Zeeman-effect, these lines (except that one of them does not show a magnetic decomposition) do not show any particularity. More observation on the pressure effect and also on the Zeeman-effect are required before the comparison of the two effects can be properly carried out. A. W.

1040. *"Grating-space" in Rock-salt and Sylvine Crystals, and Accurate Determination of X-ray Wave-lengths.* **E. Wagner.** (Ann. d. Physik, 49. 6. pp. 625–647, May 5, 1916.)—The paper commences with a discussion of the work of Moseley and Darwin, Bragg, and others, in which the well-known equation $n\lambda = 2d \sin \phi$ has been so frequently employed. The possible sources of error in the determination of the various factors involved in this equation are considered carefully and the method of *accurate* determination is described in detail. As a result of such measurements the author gives the values—

$$\lambda_{\alpha_2} = 0{\cdot}5828 \text{ Å.} \pm 0{\cdot}0001 \text{ Å.}$$
$$\lambda_{\alpha_1} = 0{\cdot}5872 \text{ Å.} \pm 0{\cdot}0001 \text{ Å.}$$

for the wave-lengths of the α_1- and α_2-lines of the K-series of palladium. Later values of other investigators are given in the following table :—

	α_1.	α_2.
Moseley	—	0·584
Bragg	0·589	0·583
Malmer	0·590	0·586

Moseley's value, $d = 2{\cdot}814 \times 10^{-8}$ cm., for rock-salt has been verified and used in the calculation of the wave-lengths above mentioned. Using this value also, the author finds the corresponding constant for sylvine (KCl) to be $3{\cdot}136 \times 10^{-8}$ cm. A. B. W.

1041. *Results of Crystal Analysis.* **L. Vegard.** (Phil. Mag. 32. pp. 65–95, July, 1916.)—In addition to some observations concerning the structure of silver [see also Abs. 1197 (1915)], gold, and lead, this paper deals mainly with the determination of the zircon group, represented by the minerals zircon ($ZrSiO_4$), rutile $(TiO_2)_2$, and tinstone (cassiterite $SnO_2)_2$. The structure of the spinal group of crystals has also been examined, the results obtained being in good accord with those of Bragg [Abs. 1197 (1915)].

In the case of gold a natural crystal was used, the lead crystal being produced artificially by precipitating lead on zinc from a solution of lead acetate. It is shown conclusively that gold and lead crystals have the same space-lattice as copper and silver, *i.e.* a face-centred lattice.

The examination of the structure of the zircon group proved to be rather complex. The observations point to the conclusion that the Zr and Si atoms are arranged in a lattice of the diamond type. An interesting deduction points to the fact that the first-order spectrum for the face (III) in the case of Ti_2O_4 and Sn_2O_4 is produced *entirely* by the oxygen atoms. After determining the arrangement of oxygen atoms in the molecules, the relative intensities of spectra of various orders are discussed theoretically, frequent reference being made to the work of W. H. and W. L. Bragg.

Considering the molecular structure of the space-lattice, it is observed that the groups SiO_2 and ZrO_2 (in the case of zircon) form the "molecular elements" of the lattice, there being also reason to believe that these groups form chemically saturated compounds.

Analysis of the structure of thorite, $ThSiO_4$ (also of the zircon group), shows that this crystal gives no X-ray reflection at all—the lattice being completely broken down, only the outer form being preserved to indicate the

atomic framework which once existed in the crystal. A crystal of this type, a "metamict" crystal, is thus isotropic, though, to all outward appearance, crystalline. A. B. W.

1042. *New Group of Lines (M series) in High-frequency Spectra.* **M. Siegbahn.** (Comptes Rendus, 162. pp. 787–788, May 22, 1916.)—In a systematic investigation of the X-ray spectrum of uranium, with the object of demonstrating the existence of wave-lengths greater than those characteristic of the L-series, the author claims to have discovered a new group of lines which correspond to the hypothetical M series. The apparatus employed, consists of a spectrograph, *in vacuo* (on account of great absorption of "M-radiation" on air); a crystal of gypsum being used as analyser. In the case of Ur the following lines were noted :—

Line.	α.	β.	γ_2.	δ_1.	δ_2.	(Ca ?)
Wave-length $\times 10^{-8}$ cm.	3·905	3·715	3·480	3·363	3·324	3·073
	and some others more feeble.					

An investigation of the elements Th, Bi, Pb, Tl, Au, shows that this series is represented in the spectra of all these elements.

Errata (Ibid. p. 892, June 5, 1916). A. B. W.

1043. *A Recording X-ray Spectrometer, and the High-frequency Spectrum of Tungsten.* **A. H. Compton.** (Phys. Rev. 7. pp. 646–659, June, 1916.)—In this paper an apparatus is described which gives a continuous record (ionisation method) of the intensity of a beam of X-rays at different angles, and a study of the X-ray spectrum of tungsten has been made to illustrate the manipulation of the instrument. The apparatus differs from the well-known Bragg X-ray spectrometer in two essentials: (1) The ionisation current due to the reflected beam of X-rays, instead of charging up an electroscope directly, goes to one pair of quadrants of an electrometer, and is shunted to earth through a high resistance. The electrometer thus acts as a highly sensitive galvanometer, a steady ionisation current producing a steady proportional deflection. (2) The angle of the crystal and the position of the ionisation chamber are varied continuously in such a manner that the ionisation chamber is always able to receive the reflected beam of X-rays, and the electrometer deflections corresponding to each particular angle of the crystal are recorded on a moving roll of photographic paper.

Using this arrangement the X-ray spectrum of tungsten has been examined in some detail. In addition to the seven lines already known, an indication has been found of six others, two of which are, however, somewhat uncertain. The wave-lengths of these lines are tabulated. The relative intensities of different lines of the same order, and of the same line in different orders, have been found from a study of the records obtained.

The observed intensities of the different orders indicates that polarisation occurs when a beam of X-rays is reflected by a crystal. A. B. W.

1044. *Symmetry of Röntgen-patterns of Tetragonal Crystals.* **H. Haga.** and **F. M. Jaeger.** (K. Akad. Amsterdam, Proc. 18. No. 8. pp. 1350–1357,

1916.)—A further paper continuing the study of the specific symmetry of the diffraction images obtained by radiating crystals of different classes.

The following tetragonal crystals have been examined :—Rutile, cassiterite, *i*-erythrite, scheelite, nickel sulphate ($6H_2O$), nickel selenate ($6H_2O$), potassium dihydrophosphate, penta-erythrite, and wulfenite. The symmetry of the Röntgen patterns for definite sections of different classes has already been deduced by the authors [see Abs. 1681 (1915)]. Reference is made to these deductions and the different crystals are discussed in the present paper.

With the exception of scheelite, and perhaps also of wulfenite—which both show an abnormal increase in their degree of symmetry, probably by twinning —there was found in all cases an agreement between the actually observed and the theoretically predicted symmetry of the Röntgen-patterns of the above tetragonal crystals. The principal correctness of the diffraction-theory is thus proved sufficiently for tetragonal crystals also. A. B. W.

1045. *Röntgen-patterns of Isomorphous Crystals.* **F. M. Jaeger** and **H. Haga.** (K. Akad. Amsterdam, Proc. 18. No. 8. pp. 1357–1364, 1916.)—A discussion is given of the results obtained by the authors on radiating through similarly orientated plane-parallel plates cut from crystals which are related to each other as direct "isomorphous" ones. The crystals studied were as follows: (*a*) The *carbonates* of calcium, strontium, barium, and lead as occurring naturally in the minerals arragonite, strontianite, witherite, and cerussite. (*b*) The *carbonates* of calcium and manganese, which are found as the ditrigonal-scalenohedrical minerals calcite and rhodochrosite. (*c*) The *sulphates* of calcium, strontium, barium, and lead in the minerals anhydrite, cœlestine, baryite, and anglesite. (*d*) The *hexahydrates* of nickel sulphate and nickel selenate. (*e*) The heptahydrates of the sulphates of zinc, magnesium, and nickel.

The results are thus reviewed :—"The general structure of the Röntgen patterns of analogously orientated sections of isomorphous crystals, appears to be a closely related one. It is confirmed that the view, after which such isomorphous crystal structures would possess similar space-lattices, in which simply a substitution of one atom species by another closely related one has occurred, appears to be highly probable and well justified. However, it cannot be denied, that under the same, or at least extremely similar circumstances of the experiment, there appear to be not only differences between the corresponding patterns on their minor details, but especially in the *number* and in the characteristic relative *distribution of the intensities* of the spots, which can only be accounted for by assuming *differences in the specific secondary radiations*, which are typical for every kind of substituting atoms especially. It is not impossible, however, that, for example, the more or less close occupation of corresponding reticular planes in those space-lattices, will moreover play a certain rôle in the whole phenomenon." A. B. W.

1046. *Emission Quanta of Characteristic X-rays.* **D. L. Webster.** (Phys. Rev. 7. pp. 599–613, June, 1916.)—It has been assumed by many authors that Planck's quantum hypothesis, when applied to the energy of kathode rays, would give the highest frequency of *a*-rays they could produce. The first accurate experimental proof of this law was given by Duane and Hunt [Abs. 1419 (1915)] and was extended to a kathode-ray potential of 110,000 volts by Hull [Abs. 336 (1916)]. The possibility that this law does not apply to characteristic rays also is indicated by the fact that Whiddington found that

the total radiation from a metal exposed to X-rays begins to increase rapidly with increasing energy of the kathode electrons when their energy is nearly 40% above that which the quantum law was later found to demand for the production of the α-lines, the strongest of the K series. A similar conclusion on X-rays from a metal exposed to kathode rays is indicated by some later work of Beatty [Abs. 606 (1913)]. As the point where this occurs is not very definite and the interpretation of the results is uncertain, it seemed desirable to test each characteristic line alone with a spectrometer. A brief report of the principal results of such a test was presented by the author to the American Physical Society in Dec. 1915. The purpose of the present paper is to report the results more fully and discuss in more detail their theoretical significance.

A series of photographs and curves are given to illustrate the main points raised in the paper. The principal experimental facts proved are :—(1) Rays of the K series of rhodium are produced only at potentials above that required to excite general radiation of a frequency equal or slightly greater than that of the γ-line. (2) Above this potential all the K lines increase in the same ratio for any given increase of potential ; their rates of increase are continually accelerated, while that of any short interval in the general spectrum is at first retarded and then nearly constant. (3) The value of Planck's "h" appears to be $6{\cdot}53 \times 10^{-27}$ erg sec. taking $e = 4{\cdot}774 \times 10^{-10}$ e.s. unit.

These results are subsequently discussed, assuming that the X-rays obey the laws of the classical electromagnetics. A. B. W.

RADIO-ACTIVITY.

1047. *Tracks of α-Particles, from Radium A, in Photographic Films.* **H. Ikeuti.** (Phil. Mag. 32. pp. 129–131, July, 1916. Math. Phys. Soc., Tōkyō, Proc. 8. pp. 465–471, June, 1916.)—When a point source of α-rays is placed on a photographic plate, the paths of radial α-rays can be traced on the film. If the rays are homogeneous, all the tracks will terminate on a spherical surface whose radius is equal to their range in the substance. The result is that the tracks appear as a halo. Haloes obtained in this way with RaC have already been illustrated in a previous paper by Kinoshita and the author [see Abs. 569 (1915)]. A description is now given of a novel method of obtaining similar photographs in which the tracks of RaA, in addition to those of RaC, are clearly visible. The ratio of the ranges of the two sets of α-particles in the film agrees remarkably well with that determined from standard measurements of the ranges in air.

Excellent photomicrographs of haloes are shown in illustration.

A. B. W.

HEAT.

1048. *Determination of the Radiation Law of a Solid by means of its Luminosity.* **T. Peczalski.** (Comptes Rendus, 162. pp. 684–686, May 1, 1916.)—In a preceding paper [see Abs. 580 (1916)] the author has established the expressions :—

$$A_1/A_2 = -\frac{T\int_{\lambda_1}^{\infty}\frac{\partial\varepsilon}{\partial T}d\lambda - n\int_{\lambda_1}^{\infty}\varepsilon d\lambda}{T\int_{0}^{\lambda_1}\frac{\partial\varepsilon}{\partial T}d\lambda - n\int_{0}^{\lambda_1}\varepsilon d\lambda} = \frac{R_1}{1-R_1}\frac{\int_{\lambda_1}^{\infty}\varepsilon d\lambda}{\int_{0}^{\lambda_1}\varepsilon\partial\lambda},$$

where A_1 is the mean absorption power between the wave-lengths 0 and λ_1, and A_2 between $\lambda = \lambda_1$ and $\lambda = \infty$; ε is the emissive power of the black body, R_1 the luminosity of the metal at temperature T, and n the exponent in the radiation law $E = \sigma T^n$. By taking $m = T\int_0^{\lambda_1}\frac{\partial\varepsilon}{\partial T}d\lambda : \int_0^{\lambda_1}\varepsilon d\lambda$, and considering the luminosity R of the black body at T (where $A_1 = A_1 = 1$ and $n = 4$), there follows $n - 4 = (m-4)(R_1 - R)/(1-R)$, m being the value of the index n of the radiation law for a body emitting radiation of wave-length between 0 and λ_1 only. The energy radiated by this body is $E_1 = wT^m = \int_0^{\lambda_1}\varepsilon d\lambda$. By differentiation the emissive power of the black body is found as a function of the temperature, viz. $\varepsilon(\lambda) = T^m\left(\frac{dw}{d\lambda} + w\frac{dm}{d\lambda}\log T\right)$. Application of these formulæ has been made to the case of liquids used as optical screens. The transparency limit for petrol is found to be $\lambda_1 = 1{\cdot}265\,\mu$. The author finally determines the exponent in the radiation law for tantalum to be $n = 4{\cdot}19$.

H. H. Ho.

1049. *The Ratio of the Two Principal Specific Heats of Gases and Vapours.* **A. Leduc.** (Journ. de Physique, 6. pp. 5–21, Jan.–Feb., 1916.)—The state of an actual gas may be represented by the equation $Mpv = RT\phi$, where M is the molecular mass of the gas, and ϕ is a function of the temperature and the pressure which may be called the relative molecular volume. Experiment shows that $\phi = 1 - mp - np^2$, m and n being functions of the temperature only, or $\phi = 1 - ez - e^2u$, where $e = 1/76$ of the reduced pressure, and z and u are functions of the reduced temperature. The equations refer to the "normal gas," *i.e.* one that obeys sensibly the law of corresponding states in the same limits of pressure. If the state of the gas or vapour is represented by $pv^{\gamma'} = \text{const.}$, it can be shown that $\gamma' = \gamma\frac{\phi}{1+np^2}$, where np^2 is negligible for gases whose critical temperature is above 100° C. Values of ϕ for some gases in the normal condition are given—

H	O	CO_2	SO_2
1·0006	0·9992	0·9934	0·9771

A variation of Clement and Désormes' method is described, and experiments are already in progress, in which all that is required is a good balance, a sensitive thermometer, and a normal barometer. The mass of the gas

being μ at temperature 0°, and μ' at temperature $t°$, it is proved that $\gamma' = (\log p_0 - \log p') / (\log \mu - \log \mu')$, from which γ can be deduced from the formulæ given above.

The next method considered is one depending on measurements of the velocity of sound in the gas or vapour, the formulæ being employed being $V = \sqrt{(RT/M \cdot \gamma \cdot \phi/p\mu)} = \phi \sqrt{[RT/M \cdot \gamma/(1 + np^2)]}$. Results are calculated for O, H, CO_2, water-vapour, benzene, and ether.

Finally a cyclic method is used to calculate the value of γ, the formulæ deduced depending on a knowledge of the max. pressure of the vapour, its latent heat, the specific heat of the liquid, and the compressibility of the vapour between the limits considered. The following results are given:—

1. Saturated Vapours.

Water.		Benzene.		Ether.	
t	γ	t	γ	t	γ
80°	1·362	40°	1·128	0°	1·071
100	1·375	60	1·130	20	1·077
120	1·378	80	1·132	30	1·081
140	1·380	100	1·136	40	1·085
160	1·375	120	1·139	60	1·096

2. Unsaturated Water-vapour at Various Pressures.

	Pressure in Atmos.					
t	1	2	3	4	5	6
160°	1·314	1·326	1·338	1·350	1·362	1·374
150	1·332	1·344	1·356	1·369	—	—
140	1·346	1·359	1·371	—	—	—
130	1·357	1·370	—	—	—	—
120	1·365	—	—	—	—	—

T. B.

1050. *Page's Theory of Heat Radiation.* **D. L. Webster.** (Phys. Rev. 8. pp. 66–69, July, 1916.)—Page has recently [Abs. 582 (1916)] brought forward a theory of heat radiation, obtaining Planck's radiation formula by a method consistent with the classical electrodynamics and not involving so many radical assumptions as Planck's theory. The author of the present paper made a similar attempt in 1915, and the two theories contain essentially the same fundamental assumptions. There are, nevertheless, certain differences between the two, and in the present note Webster concludes that Page's theory shows an apparent inconsistency with data on atomic magnitudes, does not cover such a large range of phenomena as his, and involves at least as many radical assumptions, if not more. A. W.

SOUND.

1051. *Vowel Sounds.* **A. Stefanini.** (N. Cimento, 11. pp. 229–273, March–April, 1916.)—Tuning-forks on resonance boxes are better than Helmholtz's globes; they give sharper results, and the sound continues *after* the vowel-sound has ceased, being more or less loud according to the strength of the partial. With their aid it is found that Helmholtz's theory will not hold good; a tuning-fork tuned to the alleged pitch of a vowel will or will not sound according to the pitch of the voice. But their aid calls for too many forks and too many simultaneous observers, since it is practically impossible to repeat a given vowel identically many times. The author has therefore used the strings of a grand pianoforte, with a microphonic attachment to each, and a switch governing the whole. Optical methods are unsatisfactory. With the former it was found that (1) if a string resounded to a given vowel it would resound to no other; (2) alter the pitch of the voice and a resounding string will no longer resound; (3) for some vowels a string whose natural note is lower than the pitch of the voice gives out one of its own higher harmonics; (4) when the pitch of the string and the pitch of the voice coincide, the string gives out the vowel sound strongly reinforced. For production of the vowel sound the pitch of the voice was controlled by a Marbe smoke-ring apparatus. The notes found in the complex vowel sounds of the author's speaking voice were very numerous and close together. The shape of the mouth may favour resonance of certain of the harmonics; but some of these are altogether absent when the voice has, or has not, a certain pitch. The accessory tones which make up a vowel-sound are clearly not always aliquot harmonics of the fundamental. Most of the experiments recorded have been upon vowels sung, not spoken; but the spoken vowel leaves a much more characteristic impression, say in the phonograph, than the same vowel sung. Still spoken vowels, though generically similar, differ in detail from one another. There is a certain periodicity in the different vowel-sounds; does it follow from this that the overtones are harmonics of the fundamental? If we assume perfect periodicity and the applicability of Fourier's theorem, this would follow; but the periodicity is far from perfect either as regards the wave-form or the time; and the overtones are not commensurables. Fourier's theorem implies that the components have constant amplitudes; but the curves obtained can be built up from waning osciliations periodically renewed. Further, in using Fourier's theorem we assume that the reproduction by a membrane is trustworthy, which is not the case except where the natural period of the membrane is much higher than the highest overtone in the note to be recorded. (Researches by J. B. Flowers [Abs. 797 (1916)], the whispering voice), Raps (Ann. der Physik, 10. p. 193, 1893, interference method without membrane), G. and C. Laudet [Abs. 1659 (1908)], W. E. Peters (Int. Zentralbl. f. exp. Phonetik, 23. p. 129, 1913), Benjamin (Arch. f. d. ges. Physiol., 154. p. 515, 1913, and 155. p. 436, 1914), and Zwaardemaker (Int. Zentralbl. f. exp. Phonetik, 24. p. 158, 1914) are described and criticised. On the theory of waning oscillations periodically renewed, developed by Scripturo, and especially by ter Kuile (Arch. f. d. ges. Physiol., 1913), to each pulsation of the pitch of the voice there corresponds a certain range of more rapid waning oscillations, simple (vowel *a*) or complex,

characteristic of the vowel. The author's experiments confirm this point of view. As regards resonance in the mouth-cavity we have to distinguish between this and the overtones contained in the vowel-sounds. Artificial vowel-sounds can generally be made up of a fundamental tone and a small number of overtones; but the natural vowel sounds generally contain a considerably greater number of overtones. The author's electromagnetic pendular alternator gives different artificial vowel-sounds according to the number and arrangement of the thin iron teeth which swing past an electromagnet. In a vowel-sound the predominant overtone depends on the pitch of the voice; but no clear law can be formulated. The phases of the respective waning overtones play an important part in modifying the resultant wave-form; and this affects the conclusions deducible from the application of Fourier's theorem or of Hermann's method (the position of the barocentre of the predominant overtone). These differences of phase are related to dialect, state of health, and individual peculiarities of voice. We have therefore a complete spectrum of wave-forms, shading into one another, but recognisable in different regions as the different vowel-sounds. Further, as the eye can recognise very varying mixtures of colour as giving rise to the same colour sensation, or can recognise the same words in handwriting or print differing pretty widely, so the ear recognises differently compounded vowel-sounds as being the same under varying *timbre*, expression, or dialect. This resolutive power of the ear prevents us from formulating any simple and definite law. A. D.

1052. *"Wolf-note" of Violin and 'Cello.* **C. V. Raman.** (Nature, 97. pp. 362–363, June 29, 1916.)—It has long been known that in all instruments of the violin family there is a particular note which is more difficult to excite in a satisfactory manner, and that when this "wolf-note," as it is called, is sounded, the whole body of the instrument vibrates in an unusual degree, and it seems to have been also understood that the difficulty of eliciting a smooth note of this particular pitch is due in some way to the sympathetic resonance of the instrument. In a recent paper [see Abs. 1084 (1915)], G. W. White gave experimental work confirming this view and suggested an explanation. The present author gives a different explanation and confirms it experimentally. The effect depends on the fact that when the pressure of the bow is less than a certain critical value proportionate to the rate of dissipation of energy from the string, the principal mode of the string's vibration, in which the fundamental is dominant, is incapable of being maintained and passes over into one in which the octave is prominent. When the bow sets the string in vibration the instrument is strongly excited by sympathetic resonance, and the rate of dissipation of energy increases beyond the limit up to which the bow can maintain the fundamental pre-eminent, the string's vibration accordingly changes to that in which the fundamental is feeble. Then the amplitude of the belly's vibration decreases though lagging considerably behind. The cycle is then repeated indefinitely. These views are confirmed by a photographic record of simultaneous vibrations of string and belly. E. H. B.

1053. *Aerial Waves generated by Impact.* **S. Banerji.** (Phil. Mag. 32. pp. 96–111, July, 1916.)—The intensity of the sound generated by the collision of two solid spheres varies very greatly in different directions relative to the line of impact, and the character of the sound shows a similar pronounced variation. This observation was first made with the unaided ear and communicated to the author by C. V. Raman, and the present work was under-

taken at his suggestion to investigate this effect in detail, both theoretically and experimentally. A new type of apparatus [which might be called a *ballistic phonometer*] in which the ballistic principle is utilised has been used to investigate the intensity of the sound in different directions. The results show a max. intensity in the line of the collision, practically zero intensity on the surface of the cone of semi-vertical angle 67°, and a second, but feeble, maximum in the plane perpendicular to the line of impact. These results combined with the indications of theory and further observations on the character of the sound-wave show that, practically speaking, it is produced entirely by the accelerated motion of the spheres during impact. The law of variation of the intensity of the sound with the velocity of impact and the radius of the balls has also been found and tested experimentally. It is hoped to carry out further work on the subject, particularly in the matter of getting direct records of the character of the sound-wave and observing the effects of oblique impact and the impact of spheres of unequal diameters.

The ballistic apparatus devised and employed consists of a small mirror attached to a pivoted axle whose movement is controlled by a fine spring. In practice the balance-wheel and hair-spring of a watch proved very satisfactory, the mirror being attached radially to the wheel with a little cement. The sound was received by a horn over the tubular end of which a mica disc was fixed. A sharp metal pointer was fixed normally to the centre of the disc and its end lightly touched the pivoted mirror but was not connected to it. The "throw" is read by the motion of a spot of light on a distant scale.

E. H. B.

1054. *Associated Motion of Small Bodies in Sound-waves.* **W. König** (Ann. d. Physik, 49. 6. pp. 648–652, May 5, 1916.)—E. P. Lewis and L. P. Farris recently gave a method for determining the amplitude of sound-waves in air by noting the sine graphs described by falling lycopodium [Phys. Rev. 6. pp. 491–493, 1915]. The present author examines the case and deduces formulæ giving rather different results from those derived by the experimenters. E. H. B.

1055. *Path of Sound Rays in Air under Influence of Temperature.* **V. Kommerell.** (Phys. Zeits. 17. pp. 172–175, May 1, 1916.)—A theoretical paper reaching the following results :—If the temperature changes uniformly with height, the sound rays describe a cycloid convex downward if, as is usual, temperature falls with increasing height ; but convex *upward* if the temperature increases with height. All these cycloids may be described by circles rolling on the horizontal line for which the temperature would be the absolute zero. Application of these principles to the zone of silences observed round sources of intense explosions are then discussed. E. H. B.

1056. *Propagation of Sound over Great Distances.* **G. Bigourdan.** (Comptes Rendus, 162. pp. 928–930, June 19, 1916.)—In order to clear up the causes of the occurrence of a zone of silence succeeded by a second audible region in the case of violent explosion the author here suggests a standard form of recording observations that any one favourably situated might make in the near future. E. H. B.

1057. *Propagation of Sound to Great Distances.* **G. Bigourdan.** (Comptes Rendus, 162. pp. 965–966, June 26, 1916.)—Gives further hints to observers of sounds heard, asking them to note the explosion of gun-firing, the sound of the shells in the air, the explosion of shells at great heights and at the end of its trajectory, also the explosion of mines. [See preceding Abs.] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1058. *End Effect in the Electrostriction of Cylindrical Condensers.* **E. C. Kemble.** (Phys. Rev. 7. pp. 614–624, June, 1916.)—There are two methods of computing the deformations of bodies due to the action of electrostatic fields. One method substitutes the expressions for the ponderomotive body and surface forces derived in the general theory of electrostriction into the equations of elastic equilibrium and attempts to solve those equations subject to suitable boundary conditions. This will be called the "Elasticity" method. The second method, which is essentially an energy method, makes no use of the general theory, but refers each particular problem back to fundamental principles. It assumes that the electrical and elastic state of the body can be defined with sufficient exactness by means of a finite number of co-ordinates. For example, in the problem of the elongation of a charged cylindrical condenser, the coordinates chosen are the p.d. between the coatings and a longitudinal traction to which the cylinder is supposed subjected. Hitherto the application of these two methods to the problem of the elongation of a charged cylindrical condenser has led to contradictory formulæ. Sacerdote [Abs. 1319 (1901)], using the energy method, derived a formula for the elongation of a condenser with adherent coatings in 1899 and one for the elongation of a condenser with non-adherent coatings in 1901. The first of these formulæ did not seem to be in accord with the experimental results of More and of Shearer. These experimenters found no elongation that could not be accounted for as the result of unavoidable heating, although the sensitiveness of their apparatus seemed sufficient to detect elongations of the order predicted by the Sacerdote formula. Adams [Abs. 528 (1912)], using the "elasticity" method, obtained formulæ which differed from those of Sacerdote and seemed to be in better accord with the experimental work. The author's paper proposes to show that the formulæ derived by the two different methods may be brought into agreement if the action of certain longitudinal forces due to the electric field in the neighbourhood of the ends of the armature coatings be taken into account; he also shows that the negative results of More and of Shearer are not to be interpreted as a proof that there is no such thing as electrostriction. I. W.

1059. *Mechanical Relations of Dielectric and Magnetic Polarisation.* **G. H. Livens.** (Phil. Mag. 32. pp. 162–171, July, 1916.)—There still appears to be some uncertainty as to the exact expression for the mechanical forcive of electric or magnetic origin acting on the elements of a polarisable medium in an exciting field of force, and as to the consequent reduction of this forcive to its representation by means of an applied stress system. The expression for the forcive on the polarised medium, obtained by the methods of Helmholtz, Kirchhoff, Hertz, and others is inconsistent with that obtained by Maxwell on his simpler form of the theory. The discrepancy is regarded by some authors as due to incompleteness in Maxwell's formulation, but Larmor has shown that, at least in the simplest case of isotropic media, it is due mainly to fundamental errors both in the physical assumptions on which

the energy method is based and also in the analytical processes by which that method is developed. This criticism appears, however, to have been entirely overlooked and the energy method is still very generally reproduced and it has subsequently been further developed and extended by Cohn, Gans, Sano, and others. For these reasons the author examines in closer detail the criticism of Larmor, applying it to the more general case when the law of induction is no longer linear or isotropic, but with the view rather to emphasising the underlying physical principles than of adding anything original to the criticism itself. The discussion is confined entirely to the case of dielectric media. The author holds that the theory of electric stress formulated by Helmholtz, Hertz, Cohn, and others is fundamentally at fault. In its correct analytical form it involves physical assumptions which have been long regarded as wholly untenable, besides leading to an impossible type of dielectric body forcive. Maxwell's original and simple theory is the only one that has really proved to be consistent with all the facts, among which must be included those fundamental ones concerning the electrodynamical properties of moving dielectric media, which necessitated in the first instance the introduction of the electron theory in its main aspects.

I. W.

1060. *Some Mechanical Analogies in Electricity and Magnetism.* **W. S. Franklin.** (Gen. El. Rev. 19. pp. 264–271, April, 1916. Electrician, 77. pp. 556–559, July 28, 1916.)—The phenomena dealt with in the analogies are the following:—Functions of the choke coil in the lightning arrester. Analogue of leading wattless current in a condenser. Analogue of lagging wattless current in an inductive circuit. Inductance and capacity in series. The transformer. Loose and close coupling. The electric doubler. Electricity or energy: which?

L. H. W.

1061. *Effect of the Induced Charge on the Ebert Electrometer at Kew Observatory.* **E. H. Nichols.** (Terrest. Magn. 21. pp. 87–99, June, 1916.)—A positive electric field surrounding any earthed body placed above the ground induces a negative charge on the body, and according to Swann the effect of the normal positive electric field above the ground on an Ebert electrometer decreases the measured ionic density of the negative ions, that of the positive ions remaining unaffected. Experiments were made at Kew Observatory to investigate the matter, because, according to Swann's results, the errors in measurements made with the apparatus would become very large when the potential is high, as sometimes occurs in winter.

The results of the investigations described throw doubt upon the conclusions of Swann, and suggest that when the apparatus is used as designed by the inventor the measurements made are practically unaffected by the induced negative charge, except possibly in calm weather or when potential is very high.

R. C.

DISCHARGE AND OSCILLATIONS.

1062. *Conditions of Emission of Photoelectric Currents.* **W. Gardner.** (Phys. Rev. 8. pp. 70–78, July, 1916.)—The photo-electrons emerge from a finite thickness of metal, and present a similar case to that of emission from thick films of radio-active matter. The author makes a new determination of the angular distribution of the photoelectric current from a small flat metal plate, with varying thickness of the effective substance, in order to clear up

the discrepancies in the results of Lenard (1902), Hughes (1903), and Robinson (1910). A small silver plate, connected with the negative terminal of a battery of cells (320 volts), was introduced through a ground-glass joint at one end of a small metallic cylinder, through the other end of which was introduced a small electrode or "feeler" connected with a Wilson tilted-leaf electroscope, the "feeler" being capable of revolving about the silver plate at a distance of 4 cm. Light from a mercury arc fell normally upon the silver plate, and the current received by the feeler was measured by the rate of fall of the electroscope leaf. In studying thin films the latter were deposited upon quartz by kathode disintegration. The pressure in the cylinder ranged from 0·1 to 0·001 mm. Hg. In working out the theory, the author assumes an equal emission in all directions from the molecule, a logarithmic absorption of electrons and of light, and a proportionality between the number of electrons emitted by the volume element and the intensity of light within the volume, as well as the volume itself. These assumptions lead to equations which show that the intensity of the photoelectric current increases faster with the film thickness at small values of the angle of emergence. In the thinnest films used a lack of symmetry in "incident" and "emergent" effects was not observed. The curves show a general qualitative agreement with the equations, which is all that could be expected, since the film thickness and absorption constants were unknown. E. E. F.

1063. *Photoelectric Action of Cupric Oxide.* **T. W. Case.** (New York Electr. Soc. Paper read at Annual Meeting [12 pp.], June 14, 1916.)—When a plate of clean copper and another copper plate, oxidised in a flame, are used as electrodes in a dilute solution of NaCl, a current flows from the oxidised plate to the clean plate if the former is illuminated. A plate, 3 in. by 4 in., gives 0·1 volt and a steady current of about ½ milliamp. in strong sunlight. The back of the oxidised plate should be enamelled to prevent local action. A large plate, 22 in. by 29 in., gave 0·2 amp. and 0·02 watt when it received solar energy amounting to 280 watts. This is an efficiency of 0·007 %. The amount of energy obtainable from sunlight through the medium of a horse fed on grass is 30 cals. per cm.^{2} per year. The mean solar energy received is 390,000 cals. per cm.^{2} per year. This represents an efficiency of 0·0077 %, which is nearly the same as that of the copper oxide cell. E. E. F.

1064. *Variation of Mass with Velocity of Kathode Rays.* **L. T. Jones.** (Phys. Rev. 8. pp. 52–65, July, 1916.)—The method of investigation of the variation of mass with velocity here described does not, like the methods of earlier investigators, necessitate a homogeneous kathode beam. Each photograph gives a trace of all velocities present and makes possible a verification of the law from a single photograph. The kathode beam never leaves the region between the electrostatic plates, and hence the uncertain field distribution at the ends of the plates is avoided. Rays of velocity a little greater than any previously used were employed, and the results obtained, which are illustrated graphically, favour the Lorentz-Einstein rather than the Abraham formula. A full description of the apparatus and method of operation is given, and a number of photographs are reproduced. [See also Abs. 1507 (1914).] A. W.

1065. *Initial Condition of the Corona Discharge.* **J. Kunz.** (Phys. Rev. 8. pp. 28–37, July, 1916.)—In the majority of investigations of the glow discharge of electricity from wires at high potentials alternating current has been used, and very definite empirical results have been obtained. A few researches

have been carried out on the direct corona, and Farwell [Abs. 1166B (1914)] has shown that the phenomena are far more complicated than in the case of alternating potentials. The present paper gives a description of the numerous phenomena connected with direct-current corona. The difference between positive and negative electricity appears in electrical, optical, mechanical and, probably, chemical effects. For very small wires the negative glow appears before the positive, for larger sizes the positive glow appears before the negative. The boundary between the two regions is a diam. of about 0·075 mm. The positive corona in air forms a very even uniform layer of light of practically constant thickness. The negative corona, on the other hand, starts also in a uniform layer of red light, but very quickly breaks up into bright beads, separated from each other by dark intervals. This difference between positive and negative polarity is very conspicuous at lower pressures. Experiments appear to show that the beads on smooth wire are an intrinsic phenomenon of the negative discharge. A new attempt at an explanation of some of the relations disclosed by the experiments has been made. Relations between the critical electric force at the surface of the wire, the pressure of the air, and the radius of the wire have been obtained. The constants in these relations are different for the positive and the negative wire. The principle of the conservation of energy has been applied to the ionisation pressure, and it is predicted that over a certain range the current should be directly proportional to the pressure-increase. Experimental results in verification of this prediction will shortly be published. [See also Abs. 1716 (1913).] A. W.

1066. *The Mechanism of Radiation and Propagation in Radio Communication.* **F. Lowenstein.** (Inst. Radio Eng., Proc. 4. pp. 271–280; Disc., 281, June, 1916. El. World, 68. pp. 379–380, Aug. 19, 1916. Abstract.)—The intensity of the electric field at a distance from a statically charged antenna is calculated from elementary considerations. The same quantity is derived for the case in which the charge is oscillating at a radio frequency. It is shown that the total charges acting on the receiver in the two cases have a ratio equal to the square of the ratio of the transmitting distance to a certain part of the wave-length; and hence the great advantage of the radio-frequency transmission.

The theories of Edison, Tesla, and Sommerfeld are historically considered. It is shown that there is no physical justification for the separation of the wave into surface and space waves. The electric and magnetic intensities at various distances from the antenna are calculated, and it is shown that they become practically equal at a wave-length away. The author prefers to regard radio transmission as due to conducted radio-frequency earth currents rather than modified Hertzian oscillator waves. The three distinct portions of the atmosphere: the troposphere, the stratosphere, and the coronium layer, are described, and their effect on radio transmission considered.

AUTHOR.

1067. *Electromagnetic Waves in Coils with Distributed Capacity.* **M. Siegbahn.** (Archiv f. Elektrot. 4. No. 10. pp. 305–313, 1916.)—The production of electromagnetic waves in coils with distributed capacity has recently been discussed by K. W. Wagner [Abs. 659B (1915)]. The problem is now treated with the aid of a general mathematical method due to Heaviside both for coils that are earthed at one end and for open coils. The results in the first case are found to agree with the expressions given by Wagner. Both this and

the second case lead to expressions for the potential showing that it is composed of series of oscillations of different frequencies. These expressions enable the time-variation of the potential and its space-distribution along the coils to be calculated. The arithmetical work is carried out in a special case and both the above-mentioned relations are plotted in curves. The relative frequencies of the first six harmonics are worked out for coils of different constants, and one set of constants is found to give a series of frequencies in very good agreement with an experimental series published by J. A. Fleming [Abs. 2683 (1904)]. A. J. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1068. *Thomson-effect in Incandescent Wires.* **W. König.** (Phys. Zeits. 17. pp. 227–233, June 1, 1916.)—König has previously shown how the Thomson-effect may be demonstrated in a Pt-wire bent into U-shape with the bend immersed in water [Abs. 272 (1911)]. When a current is passed down one limb and up the other the extent of the glow differs in the two limbs. The effect reverses with the current, and is due to the Thomson-effect. When mercury is employed as the cooling agent or the limbs are fixed into a block of some other metal the Peltier-effect at the metal junctions will influence the extent of the glow. In the first part of the present paper the author investigates theoretically the relative influence of Peltier- and Thomson-effects on the temperature distribution when an electric current passes along a vertical wire fixed at its lower end to the centre of a hemisphere of some other metal, the radius of the hemisphere being large compared with the radius of the wire. The chief conclusions arrived at are:—(1) The influence of the Peltier-effect diminishes and that of the Thomson-effect increases as the difference between the max. temperature of the wire and the temperature of the hemisphere increases. (2) In wires of the same material, but of varying thickness, when the current is adjusted so that the same max. temperature is attained, the influence of the Peltier-effect diminishes with the radius of the wire and the better thermal conductivity of the hemisphere.

In the second part of the paper the author describes experiments made to determine the relative influence of the two effects. Two Pt-wires, 15 cm. long and of the same thickness [1·5 mm. and 2 mm. respectively in two series of observations] were fixed vertically in an exhausted glass vessel. They were connected at the top by a copper block, and the lower end of one was fixed into an iron cylinder and the other into a nickel cylinder. These cylinders were connected by iron and nickel wires respectively to mercury cups. The current traversed in succession Fe, Pt, Cu, Pt, Ni, and the direction could be reversed. Fe and Ni were chosen as cooling metals because their Peltier-effects with Pt are of opposite sign. The relative temperature distribution along the wires was determined by an optical pyrometer method. Tables are given showing the distances from the cooling end, of points at the same temperature on each wire. The data obtained lead the author to the conclusion that in these experiments the Peltier-effect has little influence. L. L.

1069. *Determination of Thermoelectric Power by Means of a Differential Galvanometer.* **C. Benedicks.** (Comptes Rendus, 162. pp. 979–981, June 26, 1916.)—The author has previously studied the allotropy of metals by a thermoelectric method [Abs. 625 (1916)]. In the present paper he describes a suitable experimental arrangement for the determination of the thermo-

electric power of a specimen against Pt at different temperatures. To obtain a difference of temperature (dT) between two points of the specimen it is placed in a furnace consisting of a thick-walled copper tube wound with a heating coil. One half of this coil is shunted with an adjustable resistance, enabling a stationary small difference of temperature to be established. Pt-wires attached to the two points of the specimen and connected to a galvanometer give the e.m.f. (dE). To measure dT between the two points thermo-couples are employed connected to a differential galvanometer. The absolute temperature at one point is determined by a third thermo-couple.

L. L.

1070. *Dielectric Constant of Mica in Intense Fields.* **H. H. Poole.** (Phil. Mag. 32. pp. 112–129, July, 1916.)—In view of the possible analogy between electric polarisation and magnetisation, it seemed not unreasonable to suppose that some variation in the dielectric constant of a dielectric might be observed as the potential gradient approached sparking value. In this paper an account is given of experiments to test the point in question. No evidence was obtained in favour of a theory of electric polarisation analogous to the molecular theory of magnetism, except the small hysteresis effect observed. No certain variation of dielectric constant with field was established even with the most intense fields. E. H. B.

1071. *Change in Resistance of Sputtered Film after Deposition.* **E. W. Hobbs.** (Phil. Mag. 32. pp. 141–153, July, 1916.)—Thin films of Pt and Pd were produced by kathodic sputtering, and measurements were made *in situ* of the changes of resistance with time which occur when the film is left *in vacuo* and in various gases after deposition. It was found that when retained *in vacuo* a film "ages" and the resistance decreases with time in a manner which suggests that it is settling down under the action of surface tension to a more stable state [see Abs. 1248 (1912)]. The results could not be combined in any simple expression despite all efforts to control the physical conditions during and after deposition. The direct effect of exposing a film to a gas is to raise its resistance. The main change, rapid at first, is over in a few minutes after the admission of the gas, though it may continue slowly for a considerable time. It appears to be intimately connected with the taking up of gas by the film. In some cases indirect effects supervene; thus a film of Pd deposited in air at low pressure and subjected to hydrogen at atmospheric pressure shows an initial sharp rise followed by a rapid fall in resistance due to the effect on the film of the heat evolved during the absorption of hydrogen. Heat evolved during chemical combination between the hydrogen and any oxygen already present in the film has an influence, the magnitude of which depends on the nature and the past history of the film. I. W.

1072. *Verification of a Third Volta-effect and Experimental Confirmation of the Given Explanation.* **E. Sarasin** and **T. Tommasina.** (Comptes Rendus, 162. pp. 882–885, May 29, 1916.)—Previous work is first referred to for experimental details [see Abs. 604 (1916)]; then follows a concise description of the three Volta-effects and how to produce them. Experimental proof in support of the theoretical explanation is next given, and it is shown that the Volta and pile effects, which both modify the conductivity of the ionised medium, are not only of the same nature but also of the same order of magnitude from the standpoint of their potential. *Errata* (Ibid. p. 892, June 5, 1916). H. H. Ho.

1073. *Ballistic Constants of Moving-coil Galvanometers.* **P. E. Klopsteg.** (Phys. Rev. 7. pp. 633–639, June, 1916.)—The determination of the quantities involved in the equation $K = [T/2\sqrt{(\pi^2 + \lambda^2)}]k\rho^{1/\pi \tan^{-1}\pi/\lambda}$, which reduces to $K = [T/2\pi]k\sqrt{(\rho)}$ when λ is small compared with π, is easily accomplished. In these equations K = ballistic constant, ρ = ratio of one amplitude to the one next following, T = complete period, λ = log. decrement; k = current constant, i/d, where d is the deflection caused by a current i. The greater part of the error when the damping is small occurs in the value of k; with strong damping, large errors are as likely to occur in λ as in k. The above formulæ presuppose ideal conditions as to uniformity of field and symmetry of position of the coil with respect to the magnet. The author shows that these conditions are far from being realised in most galvanometers. Since, ordinarily, the field is not uniform, the value of k is not constant but depends on the angular position of the coil. The value of k to be used in the first formula above is the value which depends upon the average field intensity *at the null position of the coil.* The author suggests that it might lead to greater accuracy if, instead of producing a given deflection by means of a current, a deflection were to be produced by turning the torsion head from which the coil is suspended through a certain angle, and then the current necessary to bring the coil back to its null position determined. The coil would then be in the position in the field which it occupies at the moment of the ballistic impulse. Possible sources of error are discussed; experiments are described in which these sources of error are investigated and suggestions are made for minimising these errors. Principally the errors are due to non-uniformity of the magnetic field and to insufficient levelling of the instrument. The experimental results indicate that the method is reliable to within 0·2 %. It is suggested that galvanometers to which the method is to be applied should be provided with a tangent screw for fine adjustments of the torsion head.

I. W.

1074. *Correction for Thermoelectric Current in Ballistic Galvanometers.* **P. E. Klopsteg.** (Phys. Rev. 7. pp. 640–645, June, 1916.)—The author discusses a correction to be applied when the ballistic constant of a moving-coil galvanometer is determined by the condenser method. When the discharge to be measured takes place in the closed galvanometer circuit, the constant should be determined under similar conditions, because of the dependence of the ballistic throw upon damping. When using a standard condenser for obtaining the constant on closed circuit it is necessary, immediately after the condenser has been discharged, to connect the galvanometer through a resistance such that the total resistance is the same as it is to be in the circuit with which the measurements are to be made. Upon changing from open to closed circuit a thermoelectric current may be produced. The time of reaching the max. elongation from the null point is not the same in the case of a current of very short duration as in the case of a deflection due to a steadily impressed e.m.f. Were these time intervals alike, the correction could be made by algebraic addition of the maxima. The relation between them depends upon the amount of damping in the circuit, and is therefore different for different values of the log. decrement. Zeleny [Abs. 2082 (1906)] has given an experimental curve for correcting the observed throw and obtaining from it the magnitude of the throw which would have resulted had there been no thermo-e.m.f. in the circuit. The author deduces a theoretical relation by means of which the correction may be made and compares his method of correction with that of Zeleny. There is good agreement between the theoretical and experimental curves.

1075. *Enclosed Tungsten Arc for Ultra-violet Light.* **B. H. Morphy** and **S. R. Mullard.** (Röntgen Soc., J. 12. pp. 70–72; Disc., 72–74, July, 1916.)—Describes, with spectrograms, a "Pointolite" lamp in quartz with solid tungsten electrodes. The chief feature of the lamp is the way in which the initial striking of the arc is effected. A filament, which also forms a negative electrode, is heated by a shunt circuit, which is closed temporarily when the lamp is switched on. The ionisation which takes place allows a current to pass to the tungsten globule which forms the other electrode. This starts the arc, which can then be maintained indefinitely [see also Abs. 97B (1916)]. Running the lamp at a higher current than would be used for ordinary lighting work increases considerably the amount of ultra-violet light given out. When used even at double its normal candle-power, a life of at least 200 hours may be reasonably expected. When the arc current is about 4 amps. the output of ultra-violet light is of the same order as from the open tungsten arc. In the *discussion*, **Wilson** suggested an arc enclosed in a quartz cylinder, the electrodes being cored carbons containing calcium tungstate or other core of high atomic weight. **Schunck** suggested carbon electrodes impregnated with uranium nitrate and ammonium molybdate, which are used with the spark in photographing absorption spectra in the ultra-violet region and which give a spectrum of lines so numerous and close together that, with a slightly widened slit, an almost continuous spectrum is obtained. A. W.

1076. *Practical Installation of the Double Combination Potentiometer.* **M. Randall, F. R. v. Bichowsky, W. H. Rodebush.** (Am. Chem. Soc., J. 38. pp. 1266–1270, July, 1916.) — The paper describes the various precautions taken in the installation of a potentiometer for thermoelectric work with a view to the elimination of parasitic thermo-electric effects and leakage. By the elimination of all metal except copper in the external circuits and enclosing the instrument, parasitic thermal e.m.f.'s were reduced to less than 0·01 microvolt. The galvanometer was enclosed in a heavy sheet-copper box connected to the tin lining of the case containing the switches, rheostats, etc., thus forming a shielding system. All connections from the switches to the potentiometer were led through paraffin-filled glass tubes. The paraffin was boiled before using, then cast in thin layers, each of which was allowed to harden before a successive one was applied.

A Hulett standard battery was used as the primary source of e.m.f. in place of the lead storage cell, owing to the high temperature coefficient and variations of the e.m.f. of the latter. This necessitated a change in the auxiliary resistances, as the e.m.f. of the Hulett cell is only slightly greater than that of the standard cadmium cell. E. G.

ALTERNATING CURRENTS AND MAGNETISM.

1077. *Some Properties of Annealed Steel.* **T. Matsuda.** (Tôhoku Univ., Sci. Reports, 5. pp. 121–126, May, 1916.)—Carbon steel wires made in Tōkyō were tested as regards their mechanical properties, solubility in acid, microscopical structure, electric resistance, and magnetic property. The steel was cold drawn and then annealed at various temperatures. Its tensile strength was maximum for an annealing temperature of 200° C.; for this temperature the rigidity is a minimum. The solubility was found to be practically constant up to 500° C. (annealing temp.) and to decrease thereafter; up to 400° C. no appreciable change in the microscopical structure was observed. Above

200° a slight decrease of resistance by annealing began to take place. The results of magnetic observations show that the change in the intensity of magnetisation is roughly parallel to that in mechanical properties. The increase of the tensile strength in the vicinity of 200° C. is accordingly ascribed to the magnetic transformation of cementite. G. E. A.

1078. *Resistance of Bismuth in the Magnetic Field to Alternating and Direct Currents, and the remainder E.M.F.* **T. Heurlinger.** (Phys. Zeits. 17. pp. 221–227, June 1, 1916.)—No satisfactory theoretical explanation has been given of the varying change of resistance of bismuth in the magnetic field according as the d.c. or a.c. method of measurement is employed. The existence of an e.m.f. after the current ceases has been observed and investigated by Geipel [Abs. 1095 (1912)]. Geipel supposed the phenomena to be due to the presence of layers of some other medium between that of the pure metal. The present author does not regard such an assumption as necessary, and shows by mathematical investigation that the effects can be accounted for. He deduces equations connecting the various effects with the coefficients of the transverse thermomagnetic and galvanomagnetic phenomena and then estimates their probable magnitude. The results are in fair agreement with the experimental data obtained by various investigators. L. L.

1079. *Hall-effect and Allied Phenomena in Rare Metals and Alloys.* **A. W. Smith.** (Phys. Rev. 8. pp. 79–88, July, 1916.)—The author has measured the coefficient of the Hall-effect and the coefficient of the Nernst-effect in certain rare metals and an iron-cobalt alloy [composition Fe_2Co] and finds the following values :—

Metal.	Hall Coefficient × 10^4. Temperature 24° C.	Nernst Coefficient × 10^5. Temperature 60° C.
Indium	− 0·73	+ 3·2
Lithium	−17·0	+ 16·0
Molybdenum	+12·6	− 17·2
Tungsten	+11·8	−100·0
Cerium	+19·2	+ 10·0
Tantalum	+10·1	+ 9·8
Thallium	+ 2·4	− 3·7
Fe_2Co	+13·3	+250·0

The maximum magnetic field employed was 18,000 c.g.s. units, and except in the case of the Fe-Co alloy the coefficients are independent of the magnetic field. The direction of the Hall-effect conforms with the electron theory only in the case of indium and of lithium. The direction of the Nernst-effect in In, Li, Ce, Ta, and the Fe-Co alloy agrees with that required by the electron theory. The Fe-Co alloy was studied because of its special interest in connection with the theory that the reversal of the Hall-effect is due to molecular fields in the neighbourhood of the atoms. The value found does not support this theory. The author has also determined the Ettingshausen-effect in four series of bismuth alloys, viz. Bi-Sn, Bi-Pb, Bi-Cd, and Bi-Sb. He finds that the addition of very small quantities of Pb or Sn to Bi causes a very rapid decrease in the magnitude of the Ettingshausen-effect. Small additions of Sb or Cd to Bi increase the effect, but a maximum is soon reached and further additions rapidly diminish the effect. The Ettings-

hausen-effect in these alloys is not proportional to the magnetic field, and the deviations from proportionality are larger the greater the concentration of the added metal. L. L.

1080. *Formation of Crystals in a Magnetic Field.* **A. Tveten.** (Phys. Zeits. 17. pp. 235–237, June 1, 1916.)—The deposition of crystals of an iron compound which usually forms leaflets or tabular crystals, has been allowed to proceed in magnetic fields varying from 500 to 4500 gauss. The crystals thus formed are acicular and lie mostly with their long dimension perpendicular to the lines of force, although, too, often from an angle with its apex pointing towards the strongest part of the field; the crystals also exhibit a tendency to accumulate in the stronger parts of the field. The acicular crystals persist as long as the field, but interruption of the current is followed by separation of those crystals arranged at angles, and later by rupture of the crystals across their long direction; this disruption is completed within a few minutes and takes place whether the crystals are free from, or still immersed in, the mother liquor. Crystals formed outside are not influenced when introduced into the field. Somewhat similar results are obtained in the case of potassium ferricyanide. T. H. P.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1081. *Simple Appliance for measuring Depth of a Foreign Body.* **M[ary] Mercier.** (Archives d'Él. Médicale, 24. pp. 133–137, May, 1916.)—The apparatus consists of a wooden base to one side of which is attached a small wooden upright. Into this upright and at right angles to it pins or needles are fastened at 2 cm. apart, the first being placed at the base. The needles project on the side of the upright away from the support. To measure the depth of a foreign body the patient is placed on the operating table, the Röntgen-ray tube being below. The screen is placed above the part it is desired to examine. The apparatus is then placed at the side with the teeth turned in the direction of the foreign body. The tube is then arranged so that all the teeth appear as one on the screen; they will then be all placed on the normal ray with the foreign body. The position of the image of the latter is marked on the skin. The tube is then displaced a short distance perpendicular to the line joining the images of the teeth and foreign body. Several images of the teeth are then seen upon the screen. The image of the foreign body is displaced equally with that of the tooth situated at the same height above the table and so, by its position relative to the images formed by the teeth, its actual height above the table can be found, and when the thickness of the part under investigation is known, the depth of the foreign body below the upper surface can also be found. The readings so obtained are exact to within 5 mm. The method of obtaining radiographs is also discussed. Diagrams of the apparatus and to illustrate the methods are given. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1082. *Molecular Configuration.* **W. Ramsay.** (Roy. Soc., Proc. 92. pp. 451–462, July 1, 1916.)—It is now almost universally acknowledged that the valency of an element is due to its being associated with one or more electrons. The mechanism of chemical combination was sketched by the author in a Presidential Address to the Chemical Society [Abs. 1171 (1908)]. The conception there put forward is elaborated and illustrative models are described. Apart from the constitutional electrons there appear to be attached to each atom one, two, three, four, or five—rarely six, seven, or eight—electrons more loosely connected, which determine the valency of the atom. They differ from the constitutional electrons in so far as they are removable without disturbing the groupings which determine the essential structure of the atom as a whole. For the purpose of the present paper the atom is considered as a sphere. The valency electrons are supposed to revolve round that sphere in small circles. The rotation can be one way or another according as the atom is to be electro-positive or electro-negative. Then these spheres will naturally turn into certain positions with respect to each other, since each electronic orbit is like an equivalent magnetic shell. To represent different atoms, the orbits and periods are supposed to be different. For monovalent atoms there is but one valency electron; for a divalent atom, two electrons, and so forth. The formations of hydrogen and oxygen molecules are discussed, also ozone. Then compounds are dealt with, including H_2O, HCl, HOCl, and NH_3. E. H. B.

1083. *Viscosity and Density of Molten Metals and Alloys.* **M. Plüss.** (Zeits. Anorg. Chem. 93. pp. 1–44, Aug., 1915. Engineering, 102. p. 63, July 21, 1916. Abstract.)—The molten metal is drawn up a vertical capillary of glass which opens out into a bulb near its upper end; two marks are above and below this bulb, and the time interval is determined which the receding metal takes in passing the marks. The tube is jacketed with vapours of ether, benzene or anthracene ranging in boiling-points from 35° up to 351° C. The metal came in contact only with hydrogen or CO_2; yet there was some oxidisation sometimes, and some alloys were so viscous that wide capillaries (interval 20 or 30 secs.) had to be used instead of the original capillary of 0·03 mm. diam. (interval 100 to 300 secs.). With the wide capillaries Poiseuille's formula required the correction of Hagenbach, relative determinations being alone possible. Mercury gave Koch's viscosity-temperature curve; tin and bismuth gave almost straight lines intersecting at 31·2°, the viscosities being slightly lower than those of Fawsett [see Abs. 1566 (1908)]. The alloys examined were lead-tin, tin-bismuth, lead-antimony. The densities of the first two series (determined by weighing blocks of nickel in the alloy) were practically linear functions of the compositions, but the viscosities could not be calculated from the law of mixtures. All the three series of specially prepared alloys exhibited a sharp depression on the viscosity curve, indicating minimum viscosity at the eutectic composition, though at a temperature well above that point. The tin-bismuth series further marked two viscosity maxima corresponding to the compounds $BiSn_2$ and Bi_2Sn; none of these extreme points

coincided with density maxima. The viscosities found are higher than those of Arpi [see Abs. 596 (1914)], whose furnace was probably not of uniform temperature, and who did not apply the Hagenbach correction. H. B.

1084. *Elasticity and Strength of Steels containing High Proportions of Nickel.* **G. Colonnetti.** (Accad. Sci. Torino, Atti, 51. 2a. pp. 77–85, and 3a. pp. 150–159, 1915–1916.)—Three types of steel, containing respectively 5, 12, and 26 % of nickel, have been examined. The first is rather stronger than an ordinary steel equally rich in carbon, this advantage being sensibly increased by tempering. Steel containing 12 % Ni, after simple reheating, exhibits very high strength which is of the order of that of hard-tempered steels but it differs sharply from the latter in elastic behaviour ; the rapidity of cooling is almost without influence on the properties of the steel. The only method of diminishing the hardness and strength appears to consist in reheating at a temperature slightly below that of thermal transformation, the effect increasing with the prolongation of the heating. Before reheating at 800°, steel with 26 % Ni exhibits comparatively low strength and hardness, while the elongation is enormously greater than that of an ordinary steel of equal strength. Such elongation may be still further increased by tempering, the strength remaining almost unaltered ; this result depends on the fact that, with materials of this type, the transformation point on cooling lies below the ordinary temperature.

In the proportion of 5 %, nickel causes sensible variability in the modulus of elasticity, but tempering diminishes the modulus slightly at very low loads and raises it markedly for greater loads, so that Hooke's law is practically obeyed. Still more marked is the variability of the modulus with 12 % Ni ; the deformation increases continually more rapidly than the load, so that there are no longer limits of proportionality. The mean value of the modulus may be raised by prolonged reheating at 525°, the original hardness and strength being then restored only by heating above the transformation temperature. In the case of steel with 26 % Ni, the results are influenced appreciably, even for small strains, by the permanent deformations which always result.

T. H. P.

1085. *Structure of the Copper-Zinc and Copper-Tin Alloys.* **W. Broniewski.** (Rev. de Métallurgie, 12. pp. 961–989, Nov., 1915.)—After drawing attention to the shortcomings of the purely thermal equilibrium diagram the author reviews the results obtained on the Cu-Zn and Cu-Sn alloys by various chemical, physical, mechanical, and metallographic methods. Equilibrium diagrams, based upon the whole of the results obtained, have been drawn up for the two series of alloys. In the Cu-Zn series three compounds, viz. CuZn, $CuZn_2$, and $CuZn_6$, are formed ; they solidify at 875°, 810°, and 615° C. respectively and divide the diagram into four similar parts, each of which is typical of the separation of two solid solutions limited by a line of transition. This gives to the solid solutions ordinarily considered the following special significance : α is a solid solution of CuZn in copper, β is a solid solution consisting mainly of CuZn, γ is a solid solution built round the compound $CuZn_3$, δ is a solid solution of $CuZn_3$ in the modification of $CuZn_6$ stable at high temperatures, ε is a solid solution built up on the modification of $CuZn_6$ stable at low temperatures, and η is a solid solution of $CuZn_6$ in zinc. Copper and tin form the compounds Cu_4Sn, Cu_3Sn, and CuSn ; these give rise to the following solid solutions : α a solution of Cu_4Sn in copper, β a solution of copper in the modification of Cu_4Sn stable at high temperatures, γ a solution of Cu_3Sn in the

modification of Cu_4Sn stable at low temperatures, δ a solid solution formed principally of the modification of Cu_4Sn stable at low temperatures, η a solution of CuSn in Cu_3Sn, and H a solution of Cu_3Sn in CuSn. F. C. A. H. L.

1086. *Tungsten-Molybdenum Alloys.* **Z. Jeffries.** (Am. Inst. Mining Eng., Bull. No. 115. pp. 1225–1236, July, 1916.)—Describes a method for the determination of melting-points of metals and alloys having high fusion temperatures. The necessary apparatus is illustrated and described. The method consists in passing an electric current through a wire of the metal or alloy under examination, commencing with a low amperage and gradually increasing until fusion occurs. Voltmeter and ammeter readings are recorded with each increase in current so that the fusion wattage can be accurately calculated. The apparatus was calibrated with wires of pure Pt, Mo, and W. The melting-point of tungsten is taken as 3300° C. and of molybdenum as 2500° C. The results obtained indicate that W and Mo form a completely isomorphous series, and photomicrographs are given which are in agreement with these results. The probable accuracy of the method used and the chief causes of error are discussed.

With regard to the crystallisation of W and Mo, these are found to crystallise in the isometric system, the crystal units being cubes. Photomicrographs of etching pits are given in support of this statement. C. O. B.

1087. *Transformations occurring in the Copper-Tin Alloys in the Solid State.* **P. Slavinsky.** (Rev. de la Soc. russe de Métal. I. pp. 543–563, 1913. Rev. de Mét. 12E. pp. 405–409, Nov., 1915.)—The author has renewed the study of the copper-tin alloys over the range of composition from 57 to 77 % Cu, in order to clear up certain obscurities left by the work of Heycock and Neville and also that of Giolitti and Tavanti. Samples were prepared by casting in sand on account of the fragility of the alloys, and a thermal study was made by means of the Baikoff differential method and the Kurnakov autographic recorder. The results, which are summed up in the form of a table and a constitution diagram, point very definitely to the existence of the compound Cu_4Sn. This compound is dimorphous and undergoes an allotropic transformation at 601° C. Alloys richer in copper show two arrest-points. The temperature of the upper one varies with the composition, and is considered to be due to a decomposition of the solid solution induced by the allotropic transformation of the $CuSn_4$, while the lower one occurs at the constant temperature of 497° C., and is due to the simultaneous deposition of the alpha saturated solid solution and the remainder of the Cu_4Sn. Between Cu_4Sn and Cu_3Sn the arrest at 601° C. grows more and more feeble as the composition approaches that of Cu_3Sn. In this range the presence of the constituent Cu_3Sn is due to the reaction $3Cu_4Sn + Sn = 4Cu_3Sn$, while in the alloy corresponding to pure Cu_3Sn complete transformation to $Cu_4Sn + Sn$ occurs at 680° C. The conclusions were confirmed by micrographic analysis.

F. C. A. H. L.

1088. *Brittleness of Annealed Copper.* **W. E. Ruder.** (Frank. Inst., J. 181. p. 859, June, 1916.)—Experiments have shown that the brittleness developed on heating certain samples of copper is in reality due to deoxidation, and not to burning as is usually thought to be the case. Ordinary commercial copper begins to show brittleness at 400° C. in dry hydrogen, at 600° in wet hydrogen, at 800° to 850° in CO, and 700° in steam. Copper previously deoxidised by means of boron is not affected by heating at any temperature in a reducing atmosphere. The brittleness

is most likely due to the reduction of the intergranular cuprous oxide, leaving a spongy mass which possesses little mechanical strength.

F. C. A. H. L.

1089. *Non-ideal Solutions. The Activity of a Difficultly-soluble Component.* **E. K. Strachan.** (Am. Chem. Soc., J. 38. pp. 626–632, March, 1916.)—Deviations from the ideal law of solutions can be attributed (1) to the fact that the number of molecular species is different from the number of components by reason of association, dissociation, or combination between solvent and solute; (2) to a difference between the thermodynamic condition of the solution and of its components, commonly described as "change in the nature of the medium," or "change in the thermodynamic environment." The former differ from ideal solutions only by reason of our ignorance of their real composition: the latter give rise to solutions which are definitely "non-ideal."

The simplest of such non-ideal solutions is found in the dissolution (without association or dissociation) of a moderately-soluble solid in a normal liquid, *e.g.* iodine in CCl_4, CS_2, or $CHBr_3$. The partial pressures of these three solutions have been determined indirectly from the ratios of distribution in contact with water. The partial pressures deviate from Henry's law, but can be expressed by an equation containing an additional term, the constant for which runs very steadily through a series of concentrations and is approximately proportional to the inverse square of the solubility.

T. M. L.

1090. *Nature of Colloidal Solutions and Process for determining the Shape of Colloidal Particles.* **H. Diesselhorst** and **H. Freundlich.** (Phys. Zeits. 17. pp. 117–128, April 1, 1916.)—The paper commences with a discussion of the relationship between the Tyndall-effect and the shape of colloidal particles. With spherical particles the Tyndall-effect remains unchanged by movement of the sol, while with other shaped particles an increase or decrease of the effect can be obtained according to the experimental conditions. Flow experiments are described whereby disc- and rod-like particles have been distinguished. By movement of the sol, produced say by stirring, various formations arise, but only in the case of non-spherical particles, and these cause an alteration in the Tyndall-effect. The dependence of light absorption on the movement of sols has been investigated. With spherical particles no change in absorption can take place, but it is otherwise with disc- and rod-like particles, and transmitted light is found to give complementary effects to the Tyndall-effect. An appreciable double refraction is not necessarily bound up with the above phenomena. A weak double-refraction due to the shape of the particles must be distinguished from the much stronger effect due to the anisotropic structure of the molecule. The following sols contained spherical particles: silver, gold (red-sol by reduction with acetylene), platinum (obtained by Bredig's method), $AZ(OH)_3$ sol, As_2S_3 sol. Disc-like particles mixed with elongated and spherical particles are given by a graphite preparation of Haën, and ferric hydroxide-sol. Rod-like particles are afforded by vanadium pentoxide and tungstic acid. The results agree with those obtained by microscopic and ultra-microscopic research. Only vanadium pentoxide and ferric hydroxide, which had been prepared some time, exhibited strong double refraction, while with tungstic acid and graphite sol none could be observed. This latter offers strong support to the assumption that double refraction is intimately bound up with the anisotropic structure of the molecules which

compose the particles, and is less dependent on the shape of particles themselves. H. H. Ho.

1091. *Free Energy of Hydrochloric Acid in Aqueous Solution.* **J. H. Ellis.** (Am. Chem. Soc., J. 38. pp. 737–762, April, 1916.)—Mainly from measurements of the e.m.f.'s and temperature coefficients of concentration cells, the conclusion is drawn that the activity-coefficients both of hydrochloric acid and of potassium chloride up to a concentration of M/10 decrease far more rapidly than do the conductance ratios. The difference at this concentration is 9% for HCl and 15 % for KCl, so that in using the conductance ratio as a measure of ion-activity in mass-action expressions, as is commonly done, a corresponding error is introduced. At a concentration of about M/5 the activity-coefficient of HCl reaches a minimum, and then increases very rapidly with increasing concentration, becoming at the highest concentration (4·48 M) 2·23 times as great as at zero concentration. The activity-coefficients of KCl, on the other hand, as derived from e.m.f.'s and from freezing-points, agree together remarkably, showing that the conductance ratios of this salt are a true measure of its ion-concentrations (although not of ion-activity), since this assumption is made in the calculation from freezing-points, but not in that from e.m.f.'s. T. M. L.

1092. *The Consequences of Likening Reversible Solutions to Saturated Vapours.* **A. Colson.** (Comptes Rendus, 162. pp. 753–756, May 15, 1916.)—In applying the Clapeyron equation $Ld\mathrm{T} = \mathrm{AT}(\mathrm{V} - \mathrm{U})dp$ to solutions, the mistake is frequently made of making $\mathrm{U} = 0$, and then of applying to the truncated equation the gas law $\mathrm{PV} = \mathrm{RT}$. We ought, however, to proceed in the opposite way and to adapt the terms of the above strict quotation to the phenomena. The work $(\mathrm{V} - \mathrm{U})dp$ then refers to the expansion of a solid in the solvent at temperature T, the external pressure p being equal to the osmotic pressure of the saturated solution at T. The heat of molecular expansion L becomes the molecular heat of saturation under this pressure p. By adopting this method of procedure, the formula for reversible solutions takes the form $Ld\mathrm{T} = \mathrm{AT}[(\mathrm{V} - \mathrm{V}_1 - \mathrm{U}) + \mathrm{V}]dp$, where $(\mathrm{V} - \mathrm{V}_1 - \mathrm{U})$ represents the contraction of volume (ε) resulting from the change of state or final liquid volume minus the initial volume of the liquid and of the salt. The value of ε being negligible compared with that of the solvent (V_1), it is of little consequence whether ε is positive or negative. When now we pass from osmotic pressure to concentration, it has been customary to regard $dp/d\mathrm{T}$ as the same as $d\mathrm{C}/d\mathrm{T}$, and we obtain for non-dissociating solutes $Ld\mathrm{T} = \mathrm{AT}(\mathrm{V}_1 + \varepsilon)dp = \mathrm{KT}(1/\mathrm{C} + \varepsilon)d\mathrm{C}$, and by neglecting ε and regarding L as constant, we obtain $\mathrm{C} = \mathrm{C}_0\mathrm{T}^{1/\mathrm{K}}$. Generally, however, L is not constant and dp cannot be assimilated to $d\mathrm{C}$. It is better, therefore, to retain the original equation, which shows that when L vanishes at a temperature $\mathrm{T} + d\mathrm{T}$, the increase dp also becomes zero. But dp is the sum of two terms, $\partial p/\partial \mathrm{C} \,.\, d\mathrm{C} + \partial p/\partial \mathrm{T} \,.\, d\mathrm{T}$, and when dp is zero, $d\mathrm{C}$ is not. Or, putting it in other words, $dp = di + dn$, where i is the van't Hoff coefficient, and n the number of solute molecules in 1 litre of water. On the other hand, $d\mathrm{C} = dn$. Consequently, when L and dp are zero, the maximum of concentration, determined by $d\mathrm{C} = 0$ is not attained, since there is a real difference, di, between dp and $d\mathrm{C}$. This prediction of the theory is verified in the case of gypsum, which exhibits a maximum of solubility. Since the solubility is small, the osmotic pressure of the saturated solution is not greatly different from the ordinary atmospheric pressure, and the heat of equilibrium,

corresponding with the heat of saturation at this point, is shown by the values obtained by Berthelot, to vanish at 23°. The solubility-maximum, however, corresponding with $dC = 0$ occurs above 32°, which is in harmony with the considerations put forward by the author. [See also Abs. 136 (1916).] A. F.

1093. *Action of Nitric Acid on Aluminium.* **R. Seligman** and **P. Williams.** (Soc. Chem. Ind., J. 35. pp. 665–672, June, 1916. Chem. News, 113. p. 297, with Disc., June 23, 1916.)—The authors discuss the effect of: (1) temperature, (2) concentration, (3) impurities in the nitric acid, (4) oxides of nitrogen, (5) physical state of the metal, and (6) composition of the metal, on the reaction between nitric acid and Al. The results given show that Al can be used with advantage for dealing with strong nitric acid provided that the latter be cold and the apparatus suitably designed. With hot nitric acid of any concentration Al can have only a very limited life. Cold dilute nitric acid can be handled in Al in many cases, but the life of the Al will not be so long as with strong nitric acid. Mixed nitric and sulphuric acids attack Al much more readily than pure nitric acid, so that the metal should only be used with great caution for handling mixed acids. T. S. P.

1094. *Complete Expression for the Heat of Reversible Solution in a Volatile Liquid.* **C. Raveau.** (Comptes Rendus, 162. pp. 756–757, May 15, 1916.)—The author deduces the following equation—

$$\frac{L}{ET} = \left(\frac{\partial s}{\partial T}\right)_p \left[\frac{1}{s}(V - v)\left(\frac{\partial f}{\partial s}\right)_T + \int_p^f \frac{\partial \phi}{\partial s}\, dp\right],$$

where L = heat of reversible solution; V, v are the specific volume of the vapour of the solvent and of the solvent in the solution, under the pressure f, the concentration being s. ϕ is the volume of the solid in the solution under any pressure. On reducing the second member of the above expression to the first term, only the contraction accompanying the mixing of two solutions in the neighbourhood of the saturation-point is neglected. The formula so simplified remains strictly correct under the simultaneous equilibrium pressure of the three phases, solid, liquid, and gas. A. F.

1095. *Activity and Concentration, Transport Numbers, and Boundary Potential.* **A. L. Ferguson.** (J. Phys. Chem. 20. pp. 326–352, April, 1916.) —As a result of the present investigation, in which a new form of concentration cell was used, the author arrives at the following conclusions:—(1) The transport numbers for hydrochloric acid remain constant for dilutions greater than $n/30$, and thus conductivity measurements give an accurate method for determining ion concentrations in dilutions greater than $n/30$, so far as any change in the velocity of the ions is concerned. (2) The concentration is not proportional to activity. (3) The Nernst equation cannot be applied to an actual concentration cell without some changes. (4) The formula for calculating boundary e.m.f. gives accurate results if the true transport numbers are used and if activity is substituted in the place of concentration. L. H. W.

1096. *Some Quantitative Data on Kathode-deposited Metals.* **P. G. Nutting.** (Frank. Inst., J. 182. pp. 115–116, July, 1916.)—Platinum mirrors were deposited electrolytically on two Pt-Ir kathodes of different sizes and curves are given showing the connection between the quantity of current used and the reflecting power of the deposit at 45° incidence, the transmission (T) and the density D ($D = \log 1/T$) measured normal to the surface. Details are also given of the weights and mean densities of the deposits obtained. No mention is made of the electrolyte used. T. S. P.

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